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54 simplicity in valve controls?

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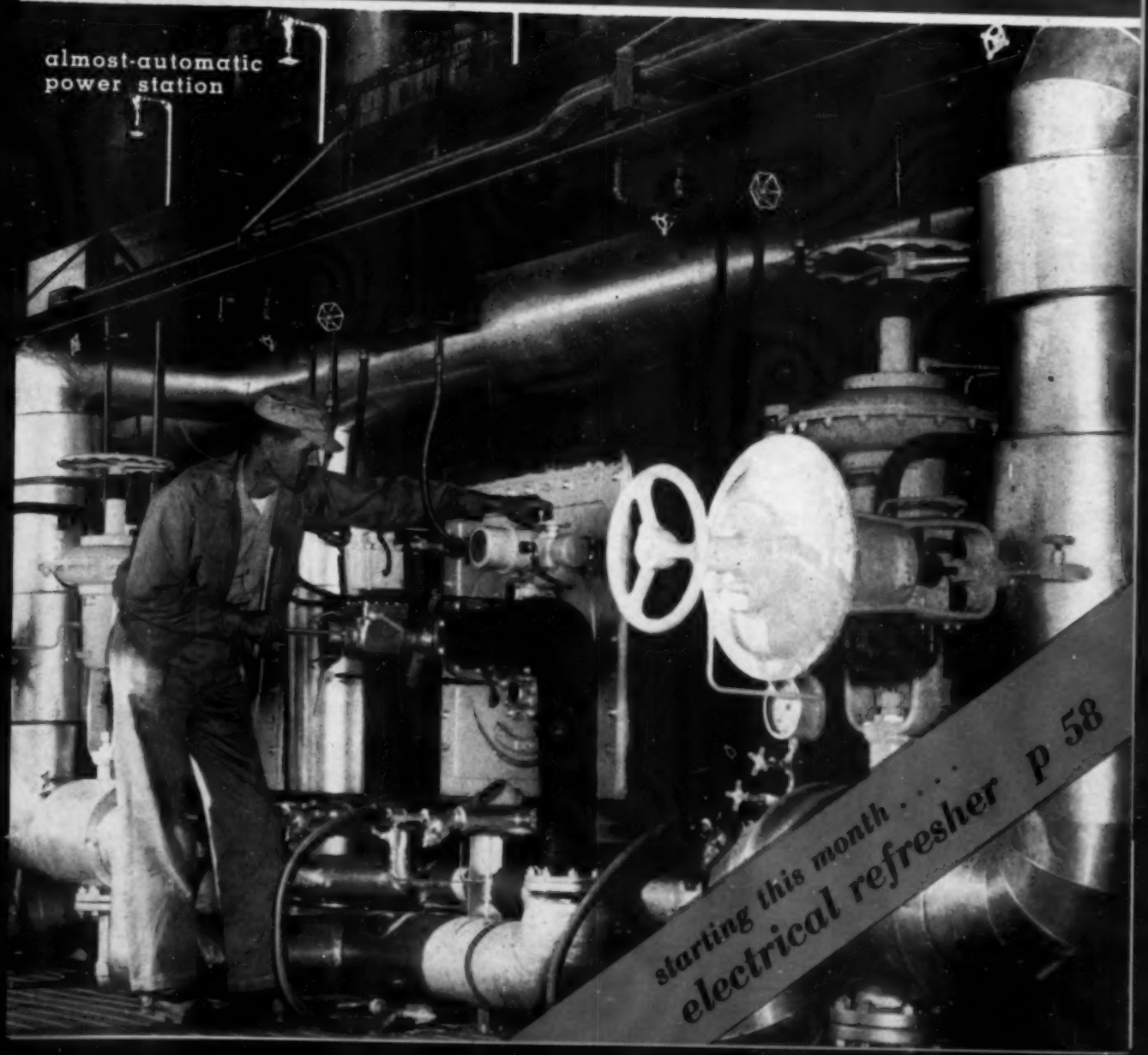
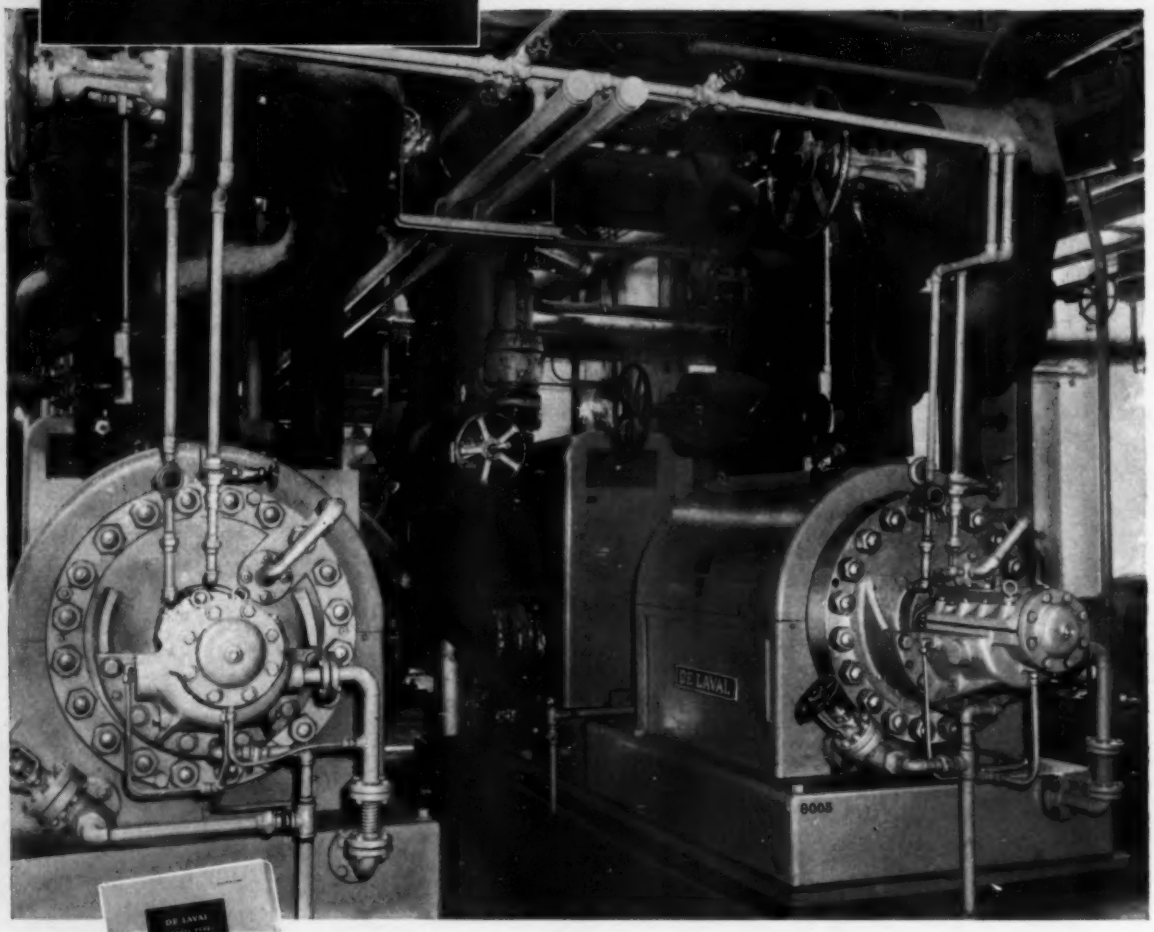
FEBRUARY 1956

Industry & Power



DE LAVAL
BARREL TYPE BOILER FEED PUMPS

give dependable service at Gaylord Container



Bulletin contains helpful data

Bulletin 1506 on the De Laval barrel type boiler feed pump covers all major design points... has cross-section cutaway illustration for easy reference. Write for your copy.

Here's additional proof of De Laval reliability on the line in the Bogalusa, La. plant of the Gaylord Container Corporation. These two De Laval barrel type boiler feed pumps are both driven by De Laval MCP turbines operating at 850 psi, with steam temperature at 825 F.

• De Laval barrel type boiler feed pumps are widely used by industrial plants and public utilities. They operate at pressures up to 5,500 psi. These units offer many important design advantages, such as double volute diaphragm, individual diaphragm bolting, positive sealing between suction and discharge chamber and bare shaft construction. Their dependability is proven by year-in, year-out service.

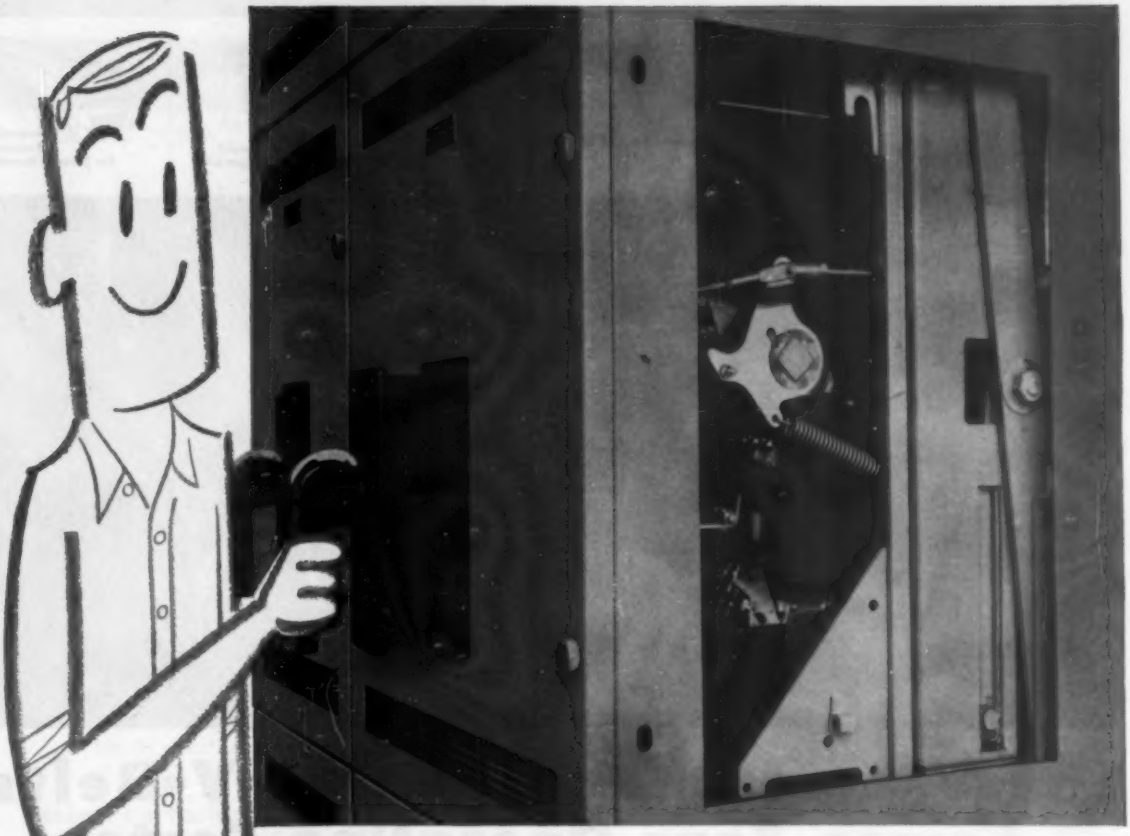
DE LAVAL *Boiler Feed Pumps*

DE LAVAL STEAM TURBINE COMPANY

857 Nottingham Way, Trenton 2, New Jersey

DL 328

Circle 132 on READ-N-CIRCLE card for more data



Now a new standard of safety in low-voltage switchgear

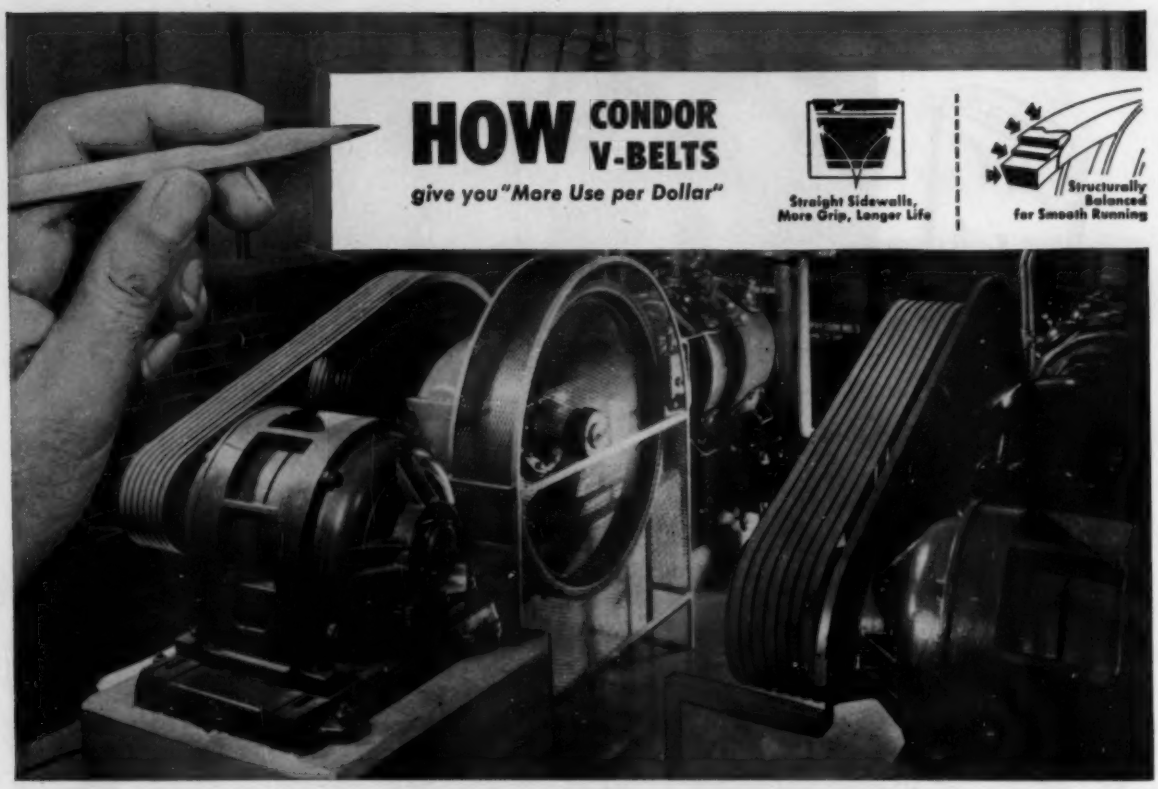
Test position with doors closed

This exclusive I-T-E low voltage switchgear feature establishes a new standard of safety in testing circuit breakers. It offers the additional advantages of reduced handling; less maintenance; convenient "tagging out"; better dust protection; easier circuit identification. And all are yours at no increase in cost in the compact, modern design of I-T-E low-voltage switchgear.

For complete information, contact your nearest I-T-E sales office. Or write for Bulletin 6004B. I-T-E Circuit Breaker Company, 19th & Hamilton Sts., Philadelphia 30, Pa.

I-T-E CIRCUIT BREAKER COMPANY
Switchgear Division

Circle 110 on READ-N-CIRCLE card for more data


HOW CONDOR V-BELTS
give you "More Use per Dollar"
Straight Sidewalls, More Grip, Longer Life
Structurally Balanced for Smooth Running

These Smoother Running V-Belts Lower Your Operating Costs

Condor V-Belt engineering makes the difference. The strength member is micro-positioned in heat dissipating rubber for a smoother running, cooler running drive ... for longer life with the heaviest power loads. Condor V-Belt sidewalls are made *straight* to put positive pressure on the sheave grooves for more grip . . . less slip. Straight sidewalls help support the super-strength synthetic cords of the belt in a straight line so that *all* cords pull equally . . . deliver their maximum share of power. Controlled length is accomplished through prestretching during manufacture to remove inelastic stretch that might otherwise occur on the job.

NOW...Moisture-Proof Vacuum Packaging

R/M's exclusive new vacuum sealed moisture-proof packaging assures positive V-belt length control for users of longer lengths in C, D & E cross sections! Belts are measured at the factory under controlled humidity and identified for precise matching. They are then vacuum-sealed in moisture-proof aluminum lined bags. The result—no shrinkage or elongation in storage . . . sustained uniformity on the drive! Length is certified from the factory to the field.

R/M Poly-V* Drive

A New Belt Drive Concept For Heavy-Duty Power Transmission. Eliminates V-belt matching problems. Delivers up to 50% more power in the same space as regular V-belts or equal power in less space.

Write for copy of Poly-V Drive Bulletin #6638.

(*Poly-V is a registered Raybestos-Manhattan trademark)

RM-606

MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.

Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings • Asbestos Textiles • Packings • Engineered Plastic, and Sintered Metal Products • Laundry Pads and Covers • Bowling Balls

Circle 128 on READ-N-CIRCLE card for more data

Industry & Power

SERVING INDUSTRY'S POWER SERVICES

VOLUME 70 NO. 2 FEBRUARY 1956

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almost completely automatic power station 35
Visit one of the most up-to-date stations in the country—read why only five men are needed to run it.

what do you know about static? 41
Learn how to stop losses that are caused by static in your plant by improving your understanding of it.

try simplicity in valve controls 54
Find out what is required of feedwater equipment and what you can expect it to do for your boiler.

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for MAINTENANCE MEN
INSTRUCTORS
and TRAINEES
in Motor Maintenance

THE methods and procedures described were developed by recognized, practicing maintenance authorities. They have been proven by conclusive evidence over many years in hundreds of operations. A concise guide, this 39-page handbook tells the practical operating man everything he needs to know about:

- Commutator and slip ring troubles and how to correct them.
- Brush maintenance and operating procedure.
- General maintenance procedure.

Dozens of illustrations show the operations described. Condensed data on IDEAL commutator and slip ring products is included.
Even if you do not have a regular maintenance training program, your people responsible for motor and generator maintenance need, and will do a better job, with the help of this handbook.

NOTE: This offer is limited to those in plant and other industrial operations. We reserve right to limit quantities furnished. Offer may be withdrawn at any time.

IDEAL INDUSTRIES, Inc. IDEAL
1023 Park Avenue, Sycamore, Ill.

Please send _____ copies of your free handbook on commutator and slip ring maintenance.

Name_____
Title_____
Company_____
Address_____
City_____ Zone_____ State_____

Circle 125 on READ-N-CIRCLE card

At times it pays to be blinded !

But certainly not when you analyze coal values. Before you contract or place an order for your coal supply, a comparative study of evaporative results should be made.

No coal is 100% efficient. But with a properly, uniformly sized coal you'll utilize a higher percentage of Btu content. This more efficient combustion means lower steam costs for you.

At our Enos and Enoco Mines . . .

specific gravity washing, exact sizing and mechanical size blending produce a coal free of loose impurities, tailored to your stoker requirements. Each shipment is guaranteed to be of the same uniform size-consist and high quality. You'll find that exactly sized, properly prepared Enos and Enoco coals reduce Btu waste.

Why not give us a call today? Let us *prove* that superior preparation of quality Enos and Enoco coals give you more efficient utilization of Btu content for lower steam cost.

Place a trial order.
Make a test comparison.

THE ENOS COAL MINING COMPANY

Sales Offices for Enos and Enoco Coals

1405 Merchants Bank Bldg. Indianapolis 4, Indiana
310 S. Michigan Ave. Chicago 4, Illinois

Circle 115 on READ-N-CIRCLE card

nuclear news

. . . about industry & power

NUCLEAR POWER PLANTS WILL COST LESS

Now, and probably until 1960, cost of building an atomic power generating plant of the boiling reactor type is estimated at between $200 and $270 per kw, according to O. B. Falls, Jr., manager-marketing for General Electric's Atomic Power Equipment Department. Cost of building a conventional-fuel steam plant of same size would be some $150 to $175 per kw. By 1980, cost of a nuclear power plant is expected to drop to about $145 to $165 per kw. By 1964, this country will require about one trillion, 40 billion kwh to meet growing energy needs. General Electric believes that energy from the atom will have to supply a great deal of that electric generating capacity.

ADEQUATE INSURANCE FOR ATOMIC ENERGY USERS

It is only a matter of time before industrialized use of atomic energy will be properly evaluated for insurance risk, with adequate coverage against major accidents and catastrophes. All branches of the fire and casualty insurance business and the National Board of Fire Underwriters have been conducting intensive research toward this goal. Progress in atomic energy program by electric utilities indicates that much of the confusion that has existed in this new industry will vanish in time with constructive thinking. It has been suggested that the Atomic Energy Commission should codify, at an early date, the layout and design of nuclear reactors and associated steam-producing equipment and their construction, installation, and maintenance. There is a growing need for establishing design, installation, inspection, and maintenance criteria for all types of reactors.

AEC ENCOURAGES PRIVATE INDUSTRY

Encouragement of private industry to build and operate plants for chemical processing of irradiated fuel elements from research and power reactors is now part of AEC's program to further private ownership of atomic energy facilities for peaceful uses. So far, only government-owned plants have been available for the chemical processing which is an integral part of nuclear reactor fuel cycle. AEC's goal is to have privately owned commercial processing plants in operation as it becomes necessary to process fuel elements from privately owned power reactors.

Pioneering new techniques
in water conditioning –
that REDUCE COSTS...
SAVE TIME...
AID PRODUCTION

■ CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

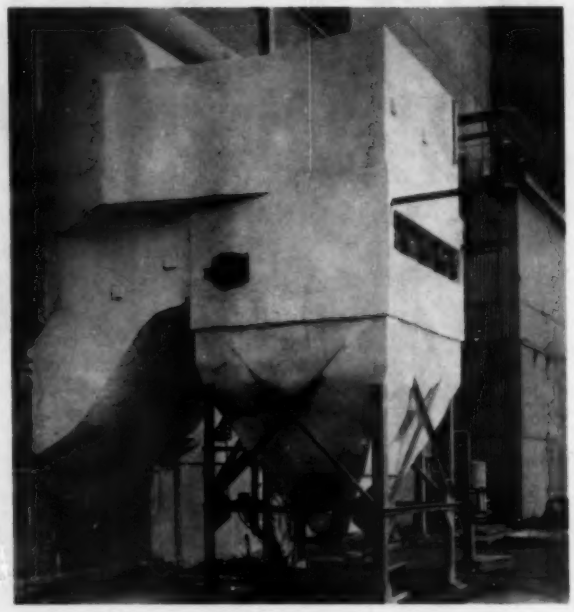
W. H. & L. D. BETZ, Philadelphia, Pa.

new products

. . . just circle key numbers on READ-N-CIRCLE card on page 67

700-Centrifugal dust collectors retain up to 97 percent particles

New multitube centrifugal separator gives efficiencies up to 97 percent. Collector consists of an inlet chamber connected directly to a nest of vertically mounted separating tubes, a dust-collecting hopper, and a clean gas discharge chamber. Unique design of inlet head and guide vanes makes for higher separation efficiency. Dust-laden gases enter collector at velocities sufficient to keep fine particles suspended. Cleaned gas goes out the stack. Almost all dust stays behind in hopper. Shape of collector tube's inlet head and guide vanes makes gas whirl in space between inner and outer shell of tube. This throws out more of the trapped dust particles than by previous methods. Cleaned gas whirls down length of tube, then moves upward and out through inner shell of tube. Dust particles, forced to outer shell by this continuous centrifugal action, flow downward and are discharged into collecting hopper. Minimum efficiency of 93 percent is guaranteed, but actual results are around 97 percent. These figures are quoted from installation burning powdered coal—and acid test for centrifugal collectors. Collector may also be used for recovery of any process dust. Separator design profits from 30 years' experience with combustion control and other problems arising from modern boiler operation. HAGAN CORPORATION.



701-Mastic coating is fire resistant

Fire-resistive mastic coating is a balanced combination of nonasphaltic fibrated polymers in nonflammable solvents. It is only mastic coating of its kind accepted by Underwriters' Laboratories for listing as fire-resistive. Material is nonflammable when wet. When dry and exposed for two minutes to violent kerosene flame, it stops smouldering within seven seconds after flame is removed. Dry mastic film retains maximum flexibility and excellent chemical resistance indefinitely. Its resistance to prolonged high heat is superior. Has proved its worth in four years' extensive application testing. Even strong winds have no effect on fire-resistive nature of this coating. Will not drip from vertical surfaces if fire is burning below. Fire-resistive mastic 60-60N is an excellent vapor barrier when used as a coating for insulation on refrigerated lines and vessels. Vapor-permeance is only .02 perm. Obtainable in natural resin color or in aluminum. Can be readily painted without sealer coat. Eliminates hazard of destructive fires caused by mastic coating being ignited by welding, cutting, and other apparently innocent sources of flame and sparks. BENJAMIN FOSTER CO.

720-Portable flue gas analyzer gives continuous readings

Portable instrument for measuring CO_2 in flue gas gives continuous readings so results of adjustments can be seen immediately. Uses a thermal conductivity analyzer cell, which electrically detects CO_2. Instrument is completely self-contained and simple to use. Useful for locating combustion troubles such as flue leaks. Eliminates high cost of a permanent installation for small furnaces. Eliminates the sampling problem. Uses any 115-volt outlet. Guaranteed for one year. THERMCO LABORATORIES.

How Olin Mathieson Uses Childers Jacketing For Insulated Lines

Jacketing problems at new plant ranged from covering tall towers to irregularly-shaped heat exchangers. Read how aluminum jacketing solved these problems.

More than 244,000 square feet of Childers .006" Jacketing and 35,000 square feet of heavy weight Childers Jacketing was used in this new Olin Mathieson plant to weatherproof insulated lines, towers and vessels. Close-up above shows how aluminum jacketing was applied with strapping and seals.

Low first-cost, long life, and easy installation were the big reasons Olin Mathieson Chemical Corporation used Childers Aluminum Jacketing for outdoor insulated lines in their new Brandenburg, Ky., petrochemical plant.

Mathieson used Childers standard weight Jacketing on their insulated lines. Heavier weights of Childers Jacketing were used on high towers and vessels where a stiffer material was needed to support the vertical weight of the jacketing.

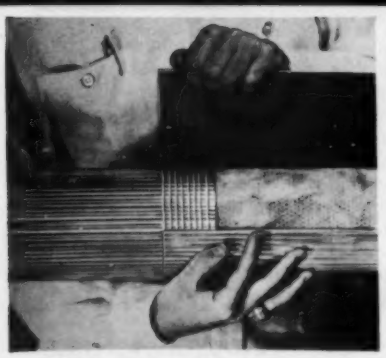
Engineers report that Childers Jacketing is inexpensive to apply. It comes in easy-to-handle rolls 4 ft. wide and 100 ft. long. Just pliers and a pocketknife are the only tools needed to apply. And because the jacketing is aluminum it needs no painting . . . stays clean and new looking even after years of service.

Childers Jacketing is easily removable, too. Just remove the strapping and jacketing can be taken off for inspection of the lines. Then same jacketing can easily be put back on the insulated line.

Immediate shipment from our large factory stocks can eliminate costly delays in construction or plant improvement schedules.

Try this low-cost protection in your plant. Write today for engineering data and information. You can order a 400 sq. ft. roll to test on one of your insulated lines. No obligation. Address: Childers Manufacturing Company, Department IP-8, 3620 West 11th St., Houston, Texas.

Only Childers Jacketing Offers *LAP-SEAL*

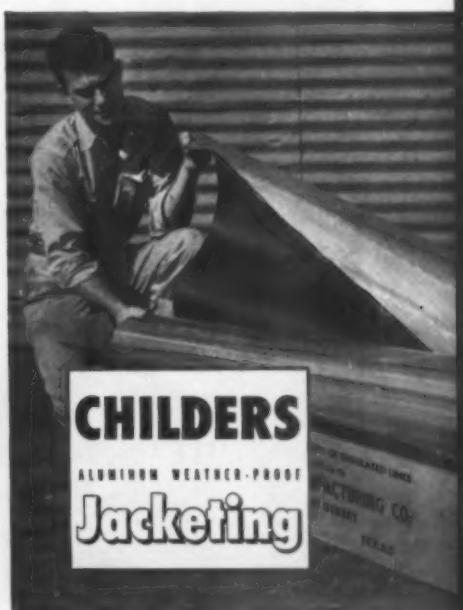


LAP-SEAL is a series of eight ribs rolled into the underlapping edge of the jacketing.

LAP-SEAL makes more positive weather seal.

LAP-SEAL saves labor—2" ribbed edge eliminates measuring for circumferential lap.

LAP-SEAL (patent applied for) is an exclusive "plus" available on all Childers Jacketing at no extra cost.



Each roll of Childers Jacketing comes individually packed like this in a heavy corrugated carton. Rolls are 4 ft. wide. With moisture barrier attached they are 100 ft. long; without moisture barrier they are 200 ft. long. They are well protected for field storage if kept dry. Individual boxes are light enough for one man to handle. (Adv.)

Circle 107 on READ-N-CIRCLE card for more data

new products

. . . starts on page 8

702-Plug-in strip handles branch circuit

Plug-in strip is offered with integral raceway for branch circuit conductors. Provides electrical outlets also, and is approved for 110- and

220-volt service. Branch circuits may be run in the same duct carrying plug-in strip harness. Very adaptable to air-conditioning installations. NATIONAL ELECTRIC PRODUCTS CORPORATION.

703-Package boiler return system reduces steam costs

Package boiler return system uses heat and energy from high-pressure condensate to preheat incoming water for processing. Recapturing this heat, which might otherwise be lost in

steam flashing off, saves steam and fuel costs. Unit also reheats condensate and makeup water to near steaming temperature and returns it to boiler. THE PATTERSON-KELLEY CO., INC.

704-Recondition wood surfaces cheaply and quickly

Laborsaving, low-cost solution to old problem of maintaining and upgrading wood, metal, and masonry surfaces is now available with a new 100-percent solids resin coating named Glid-Iron. Beside having excellent adhesion to wood, metal, and concrete, the product is highly resistant to chemicals, making it ideal as a floor coating in food processing, plating, and chemical plants. It also protects concrete silos from destructive and corrosive effect of silage. Application costs around 15 to 19¢ /sq ft, compared with up to 35¢/ sq ft with other methods. May be applied by spray, brush, roller, or squeegee in any thickness up to ½ inch if desired. Product smooths out and bridges small cracks, then sets to a hard, tough, flexible and scuff-resistant finish after curing overnight. THE GLIDDEN COMPANY.

705-Airfoil fans use less power, give less noise

Airfoil centrifugal fans give efficiencies above 92 percent and operate on 35 percent less power than required by conventional flat-blade fans of same capacity. Noise level is

reduced 65 percent. Backward curve, nonoverloading fan features new hollow-sectioned aerodynamic-shaped airfoil blades. Entirely eliminates eddy currents. Comes with wheel sizes 13½ to 143 inches diameter. Air deliveries to 1 million cfm. CHICAGO BLOWER CORPORATION.

706-Grating serves as sun shades

Lightweight aluminum grating allows 80-percent passage of light and

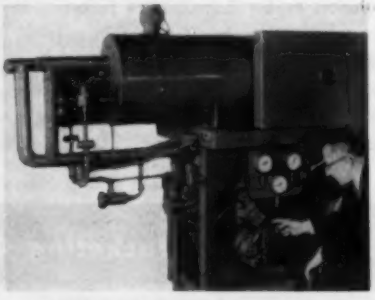
air but cuts off penetrating sun rays. In some applications, it also serves as a permanent working platform. BORDEN METAL PRODUCTS CO.

FREE INFORMATION

For detailed free information on these products just circle the key numbers on the READ-N-CIRCLE card on page 67.

707-Package liquid chillers pack more capacity per cubic foot

Package liquid chillers that come complete with compressor are especially designed for modern refrigerants. Units include compressor, motor, chiller, condenser, heat exchanger, and all necessary controls. New C series Flow-Therm units use



new Dry-Ex liquid chiller, which is smaller and lighter. Has 25 percent more cooling capacity per cu ft of chiller volume. Compressor, condenser, and heat exchanger are balanced in size to put maximum capacity in minimum space. Capacities range from 20 to 175 tons. Units are completely assembled and factory tested —ready for installation and immediate operation after charging with refrigerant. ACME INDUSTRIES, INC.

Air Casualties

It's bad air that does it. But you can step up production by putting a Coppus Blower on the job to keep the air moving — and keep the men cool.

The kind of air a man works in has a lot to do with how much work he can turn out.

In confined places like shipholds or tanks or drums or boilers . . . or wherever the air is stagnant or hot or full of fumes . . . a Coppus Blower is a *must* for getting first-class work out of the men, all the time.

A Coppus Blower or Exhauster helps avoid sickness and lassitude due to bad air . . . and improves morale, too.

Portable and adaptable for special purposes, Coppus Blowers and Exhausters will have dozens of uses around your plant. The "Blue Ribbon" (a blue painted band) is your assurance of quality performance at lowest cost.

COPPUS

BLUE RIBBON BLOWERS

THE BLOWERS THAT PUT MORE MINUTES IN EVERY MAN-HOUR

CABLE MANHOLE AND TANK VENTILATORS — BOILER MANHOLE BLOWERS AND EXHAUSTERS — HEAT KILLERS — SHIPHOLD VENTILATORS . . . DESIGNED FOR YOUR INDUSTRY — ENGINEERED FOR YOU

MAIL THIS COUPON To Coppus Engineering Corp., 182 Park Avenue, Worcester 2, Mass. Sales offices in THOMAS' REGISTER. Other "Blue Ribbon" Products in BEST'S SAFETY DIRECTORY.

PLEASE SEND ME INFORMATION ON SUPPLYING FRESH AIR TO MEN WORKING:

- ☐ in tanks, tank cars, drums, etc.
- ☐ in underground cable manholes.
- ☐ in aeroplane fuslages, wings, etc.
- ☐ on coke ovens.
- ☐ on steam-heated rubber processes.
- ☐ on boiler repair jobs.

COOLING:

- ☐ motors, generators, switchboards.
- ☐ wires and sheets.
- ☐ general man cooling.
- ☐ around cracking stills.
- ☐ exhausting welding fumes.
- ☐ stirring up stagnant air wherever men are working or material is drying.
- ☐ drying of walls, sheets, etc., after treated with coating material.

NAME .....

COMPANY .....

ADDRESS .....

CITY .....

(Write here any special ventilating problem you may have.)

Circle 101 on READ-N-CIRCLE card for more data

Full 180° Visibility Accuracy to ½ of 1%

You get full 180° visibility with the new Jerguson Truscale Gages with the Convex Scale. Scale markings are directly on the convex face and the indicator goes clear around the convex surface. You can bring your liquid level down to the control room floor, or other remote point . . . and can see it from anywhere in the room . . . can check a whole line-up of Truscales with one look from any point.

Truscale is really accurate too . . . sensitive to ½ of 1% of scale reading. Simple trouble-free construction. Available with signal horns, lights and up to six repeaters for other auxiliary points.

New design boiler water gage gives maximum visibility

Jerguson's unique offset single piece gage chamber gives you more inches of visibility with no blind spots. Special valve with horizontal loop keeps the strain off the gage under varying conditions of expansion and contraction.

Send for complete data on Jerguson Convex Scale Truscales . . . and Boiler Water Gages.

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY
100 Fellsway, Somerville 45, Mass.

Offices in Major Cities
Bailey Meters & Controls, Ltd., London, Eng.
Controle Bailey, Paris, France

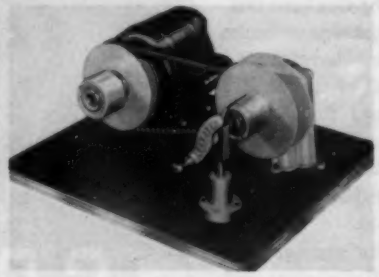
Circle 102 on READ-N-CIRCLE card

new products

. . . starts on page 8

708-Compound drive provides constant belt alignment

Compound drive that provides constant belt alignment through its entire speed range up to 8:1 ratio uses



a ⅞ inch top width or A belt as standard. Available in either spring-loaded or manually operated design. Manually operated units come with either pedestal stand or hydraulic yoke. LOVEJOY FLEXIBLE COUPLING CO.

709-Emergency roof repairs possible in winter

Emergency repair kit for stopping unexpected winter roof leaks is adaptable to both wet surface and low-temperature applications. Materials in new kit permit fixing roof immediately upon detection of defect—

without waiting for favorable weather. Kit can be used in driving rainstorms or snowfalls and at temperatures as much as 20 F below those at which ordinary roofing materials can be applied. May be put on with brush or squeegee. THE MONROE COMPANY, INC.

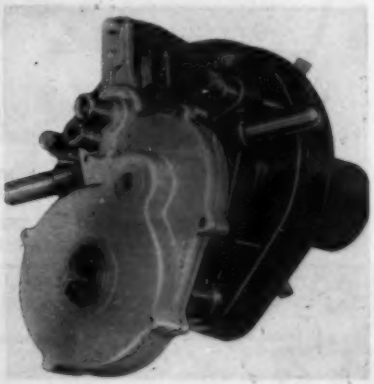
710-Rotary pressure joint has two ball bearings

Improved rotary joint, with two ball bearings to support and guide revolving shaft axially, prevents mis-

alignment and wobbling of shaft. Continuous leakproof performance is assured. Also has a tamperproof metal seal. In sizes from ⅜ to 2 inch IPS. SEAMLEX COMPANY, INC.

711-Pipe threader power unit is versatile

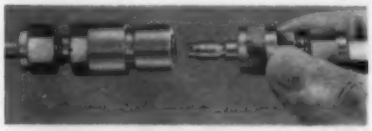
Power unit for pipe threaders also may be used to pull cable, operate pulleys, hoists, and conveyors, or to roll boiler tubes. Porta-Drive will power all standard gear pipe threaders. Unit has a 20:1 gear ratio and



is reversible. Threads 1- to 2-inch pipe using adapters, and will thread 2½- to 6-inch pipe with or without a vise. Can be used on most workbenches. In absence of power can be operated with an ordinary carpenter's brace. Weighs only 14 pounds, so can be easily carried to the job. Sets up simply and quickly for use in shop or out. MUNCIE GEAR WORKS, INC.

712-Quick connect fitting needs no tools

Quick connect fitting that can be connected or disconnected without tools uses a shutoff valve as a positive seal to prevent leakage during the operation. Internal design allows



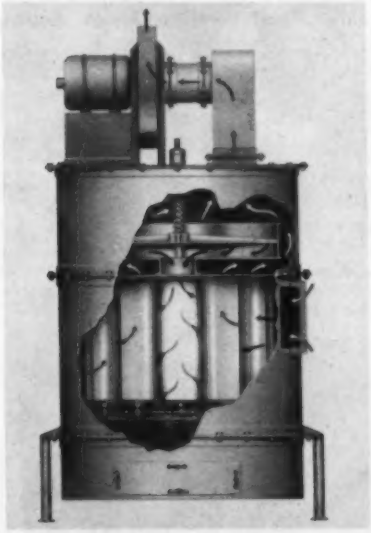
freer flow than is possible with ordinary fittings of similar type. Available in all metals for use with plastic and metal tubing. Comes in standard sizes and in three types—tube to tube with Swagelok end, tube to pipe with one Swagelok end, and tube to tube or tube to pipe. CRAWFORD FITTING CO.

FREE INFORMATION

For detailed free information on these products just circle the key numbers on the READ-N-CIRCLE card on page 67.

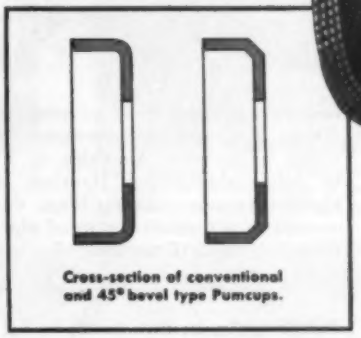
713-Low-cost dust filter needs no shutdown

Type RJ automatic continuous disc filter is excellent with continuous process equipment because no shut-



down is needed for rapping or cleaning. Hersey principle of high-velocity reverse air cleaning gives filter an efficiency over 99.99 percent. Dust is deposited on outside of 12 filter sleeves made of felted materials. THE DAY COMPANY.

2-way gain with PUMCUPS



Cross-section of conventional and 45° bevel type Pumcups.

Darcova Pumcups are available in various types and textures, in a complete range of sizes, to provide unequalled efficiency and long life in reciprocating pumps, air or hydraulic mechanisms.

★ prolonged high efficiency
★ less maintenance

TODAY hundreds of companies using hydraulic controls, air cylinders or reciprocating pumps are *standardizing* on Darcova Pumcups for piston packing, because they eliminate fluid slippage, costly down-time and maintenance.

Darcova Pumcups make the *most* of the cup packing principle. And, they are made in a complete range of sizes, types and texture-engineered compositions for various pressure-temperature-fluid conditions. Pumcups hold peak efficiency for the life of the cups and outlast other packing as much as 3 to 1.

Why not check these claims right in your own plant? Meanwhile get *all* the facts. Just send for Pumcup Bulletin No. 5503.

DARLING VALVE & MANUFACTURING CO.
Williamsport 9, Pa.

DARCOVA THE ORIGINAL COMPOSITION CUP

TRADE MARK PUMCUPS

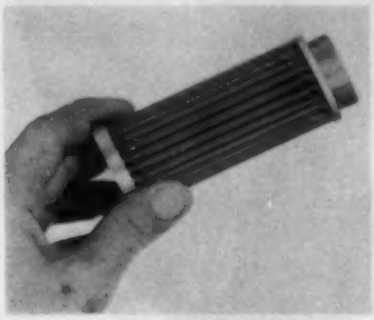
Circle 133 on READ-N-CIRCLE card for more data

new products

. . . starts on page 8

714-Sintered filter good up to 1000 F

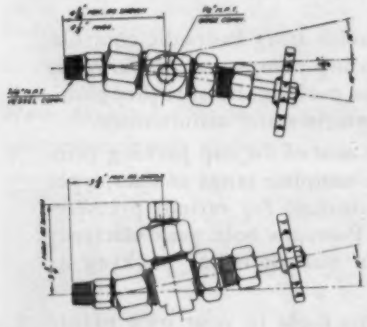
Sintered filter is capable of handling fluids up to 1000 F. Removes particles as small as one micron from



even strong acids and alkalies. For pressures to 500 psi. Comes with either internal or external threads which eliminates packings and leakages. PUROLATOR PRODUCTS, INC.

715-Spherical union for valves compensates misalignment

Spherical union connection for valves compensates for up to ten degree misalignment of vessel tappings in any direction from perpendicular axis and a wide variation in centers.



When used with side-connected gages, spherical union on tank connection side of valve alone permits ±3/8 inch variation per valve. JERGUSON GAGE & VALVE CO.

716-Plugs, receptacles, connectors are submersible

All-weather heavy-duty submersible plugs, receptacles, and cable con-

nectors withstand most adverse conditions of temperature, corrosion, and water submersion. Available in 3 to 60 pole combinations. Housings are highly corrosive-resistant brass, thick enough to withstand abnormal abuse. PYLE-NATIONAL COMPANY.

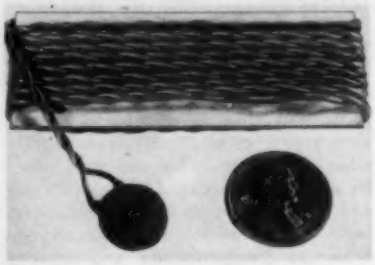
717-Electric brake needs no maintenance

New electric brake features a magnet with circumferentially wound core and armature that reduces power losses by 80 percent compared with usual E-magnet system. Preformed coils inserted in slots milled in core

are equivalent of six E magnets. Because this number is divisible by two or three, brake may be connected to either two- or three-phase motors with equal ease. STAR-KIMBLE, MOTOR DIV., MIEHLE PRINTING PRESS & MFG. COMPANY.

718-Heat flow disc has high sensitivity

New heat flow disc, made of a special tellurium alloy and smaller than a penny, is so sensitive that one Btu /sq ft/hr generates 2.5 microvolts. The JLC-Hatfield Heatflow Disc is core of several temperature control and indicating instruments. Disc has low



thermal and electrical resistance because of its wafer-thin and single junction construction. Internal impedance is one ohm. Thermal resistance is 0.009 F/Btu/hr/sq ft. Disc loses or gains heat almost exactly as surface to which it is applied. To increase output or to average measurements over a wide area, several discs may be connected in series. NATIONAL INSTRUMENT LABORATORIES, INC.

719-Control valve has reversible superstructure

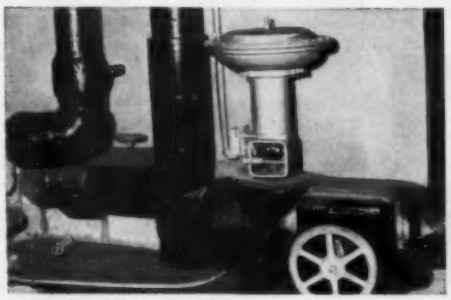
Single seat control valves in nominal sizes from ½ through 8 inches have extra large bowl capacity to insure a high flow coefficient. Action

may be reversed by inverting superstructure, without interfering with the open or yoke packing. HAMMEL-DAHL COMPANY.

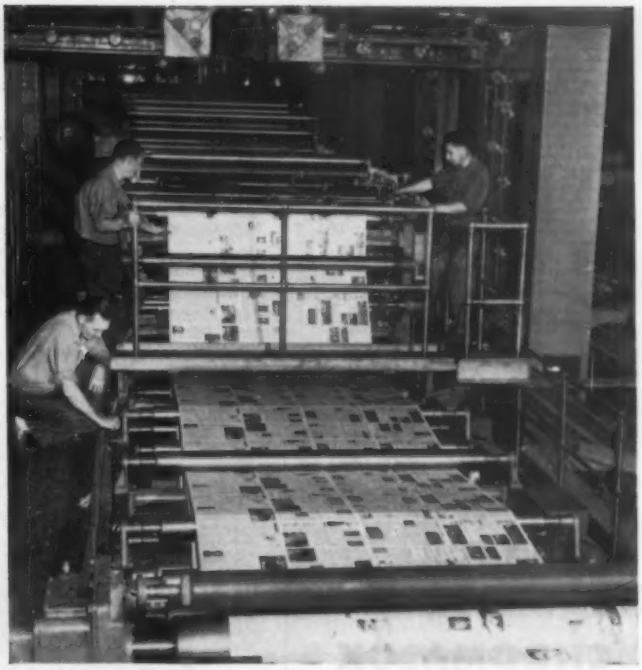
FREE INFORMATION

For detailed free information on these products just circle the key numbers on the READ-N-CIRCLE card on page 67.

Rotogravure Building, Triangle Publications, Inc., Philadelphia. Albert Kahn Associated Architects & Engineers, architects and engineers, Detroit; Eggly-Furlow Engineers, mechanical engineers, Philadelphia.

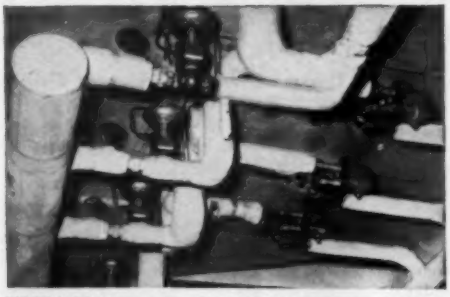


AIR CONDITIONING. A Johnson 3-Way Mixing Valve, with Pilot Positioner, gives precision control of chilled water supply to a unit serving a processing area.

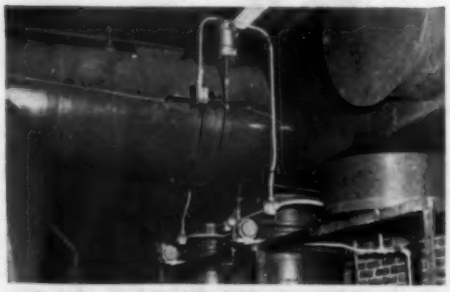


HEATING and VENTILATING. Strategically located Johnson Thermostats regulate heating and ventilating systems for huge press rooms housing 61 giant, high speed press units. Johnson Humidostats closely control relative humidity also.

INTRICATE CONTROL PROBLEMS CORRECTLY SOLVED by JOHNSON



REHEAT COILS are controlled by Johnson Steam Valves in response to demands from Room Thermostats. Pilot Positioners provide maximum, accurate repositioning power.



SOLVENT RECOVERY SYSTEM receives vapor-laden air at rate of 1500 cfm from each press unit. Johnson Static Pressure Regulators and Damper Operators help insure safe air movement through enormous duct system.

Triangle Publications' impressive Rotogravure Building is one of the largest and best equipped gravure plants in the world.

Dependable control of temperatures and humidities is essential in an operation this size. Processing requirements, product protection, worker comfort, safety and operating costs are among the complex factors which must be resolved correctly.

A Johnson-engineered Control System, in command of 25 central heating, ventilating and air conditioning systems, solves all of these problems with precision, satisfying the exact needs of such diversified spaces as press rooms, paper storage, etching and developing rooms, private and general offices and cafeteria.

In addition, other Johnson controllers are applied to the solvent recovery, waste paper pneumatic conveyor, paper handling, ink handling and exhaust systems.

How about your control problems? Whether they involve a simple application of one or a few controllers, or the installation of an intricate temperature, humidity or process control *system*, look to Johnson for the correct answer. An engineer from a nearby Johnson branch will gladly give you his recommendations without obligation. Johnson Service Company, Milwaukee 1, Wisconsin. Direct Branch Offices in Principal Cities.

JOHNSON CONTROL

TEMPERATURE AIR CONDITIONING

PLANNING • MANUFACTURING • INSTALLING • SINCE 1885

Circle 120 on READ-N-CIRCLE card for more data

What's your need for heat?

Whatever your heating job may be, you'll find the efficient, economical answer in . . .

CHROMALOX Electric Heaters

. . . for heating platens, dies, molds, metal parts . . . for heating liquids, air, gases . . . for curing, drying, baking . . . for comfort heating in offices and factories . . . for special applications . . . in fact for any application requiring fast, low-cost, controlled heat up to 1100°F.

IMMEDIATE DELIVERY

from the world's largest factory stock of industrial electric heaters . . . over 15,000 types, sizes and ratings.

Let the Chromalox Sales-Engineering staff solve your heating problems . . . electrically.

Write for your copy of Catalog 50

Contains helpful information on design uses, and prices of Chromalox Electric heaters, elements, thermostats, contactors and switches.

To get some interesting facts about additional applications of electric heat, ask for Booklet F1550—"101 Ways to Apply Electric Heat."

Edwin L. Wiegand Company
7520 Thomas Boulevard, Pittsburgh 8, Pennsylvania

EDWIN L. WIEGAND COMPANY
7520 Thomas Boulevard, Pittsburgh 8, Pa.

I would like to have—

☐ A copy of Catalog 50
☐ A copy of "101 Ways"
☐ A Sales-Engineer contact me

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Company_____
Street_____
City_____ Zone____ State_____

A-4455A

Circle 113 on READ-N-CIRCLE card

names make news

. . . personalities from industry & power

American Air Filter Company names officers. **W. M. Reed,** former president, becomes chairman of the board. **W. G. Frank,** formerly executive vice president, becomes president. **Ben R. Shaver,** former secretary-treasurer, becomes vice president and treasurer. **E. G. Mason,** former assistant secretary-treasurer, becomes secretary.

Couch

Heller

LeRoi Division of **Westinghouse Air Brake Company** appoints **Edward R. Couch** manager of stationary compressor sales. Couch was formerly assistant product sales manager with Industrial Products Division. His new duties include planning stationary compressor sales, assisting in promoting distributor sales, and assisting field personnel on special applications.

Taylor Instrument Companies appoint **George E. Heller** to assistant industrial sales manager. Heller's duties involve field organization and new product introduction. He was formerly division sales manager in chemical and petroleum sales.

Strong Steam Specialty Mfg. Co., subsidiary of **Strong, Carlisle & Hammond Company,** elects **R. L. Clark** president. Clark will be responsible for engineering, research, development, and production. **H. H. Maltbie** is promoted to sales manager, Steam Specialty Division.

American Standards Association elects **H. Thomas Hallowell, Jr.,** president, Standard Pressed Steel Company, to the office of president. **Van H. Leichliter,** vice president of operations, American Steel and Wire Division, United States Steel Corporation, is elected to the office of vice president.

Darling Valve & Manufacturing Company regretfully announces the death of its president, **Marshall L. Hough.** Hough was president and treasurer of the company for the past 20 years and was widely known throughout the valve industry and industries served by his company's products.

Coal Producers Committee for Smoke Abatement elects **R. L. Ireland** chairman of the general committee. Ireland is presently chairman of the executive committee, Pittsburgh Consolidation Coal Company.

Worthington Corporation advances **William C. Osborne** to manager of engineering of Harrison Division, and **Everett C. Schmachtenberg,** assistant to manager of engineering. **R. K. Grobholz** is appointed manager of Power Pump Sales Division.

Claude B. Schneible Company appoints **R. Grant Whitehead** sales manager. Whitehead was formerly assistant to sales manager. He is well known in the foundry industry and to users of dust collection equipment.

General Electric Company announces retirement of **Nicholas M. Du Chemin.** DuChemin rose from apprentice to vice president during his 41 years with the company. He is a member of AIEE and ASME.

Thomas A. Edison Instrument Division appoints **William H. Balentine** to newly created post as manager of plant operations. Balentine was formerly assistant to division manager.

Mitchell

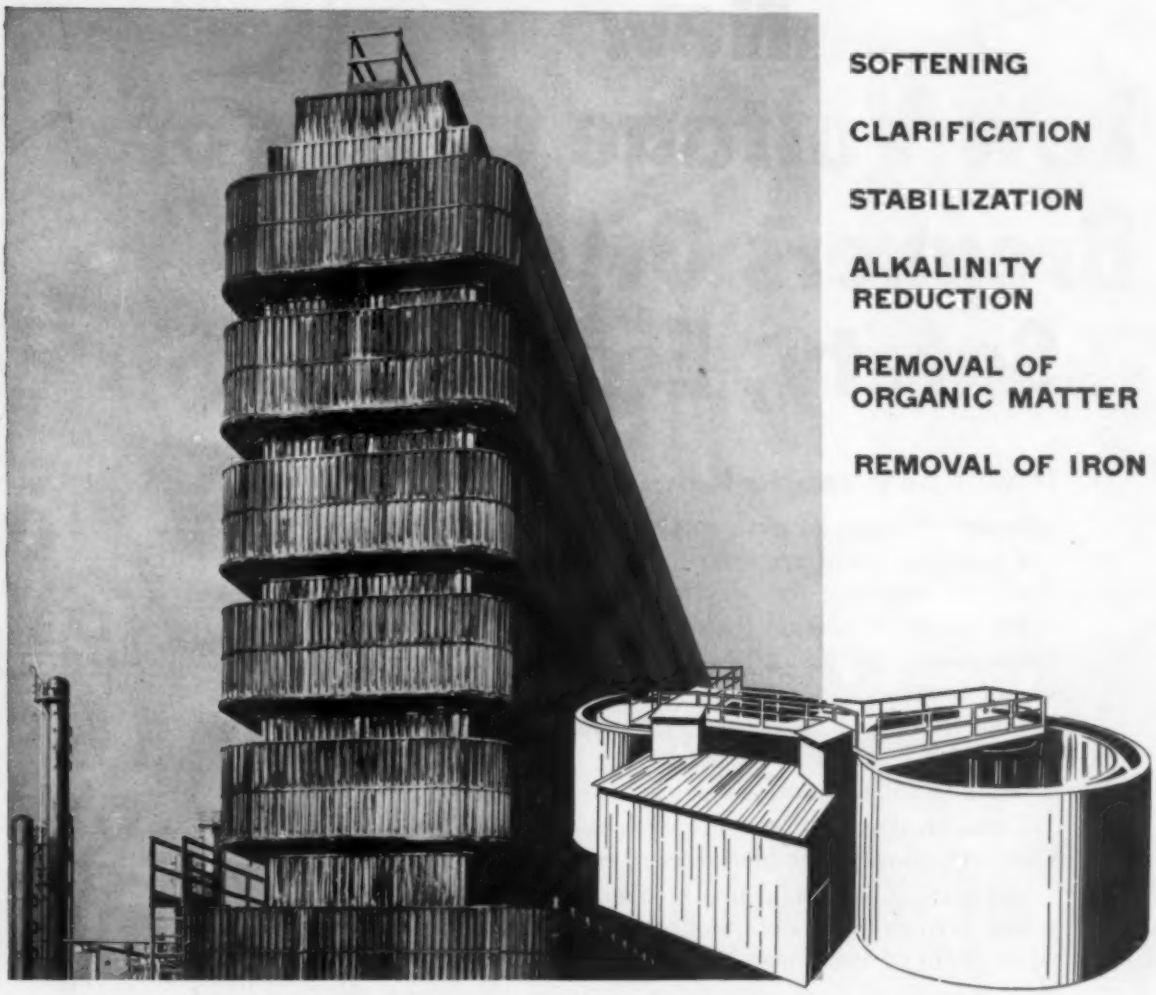
Ewert

Burns and Roe, Inc., consulting engineers and constructors, elects **L. F. A. Mitchell** vice president. Mitchell had been director in charge of company's commercial activities since 1954.

Foote Bros. Gear and Machine Corporation appoints **Richard H. Ewert** to newly created position of manager. Ewert is a member of ASME and Western Society of Engineers.

COOLING WATER PROBLEMS?

Let INFILCO engineers help you on...



SOFTENING

CLARIFICATION

STABILIZATION

ALKALINITY REDUCTION

REMOVAL OF ORGANIC MATTER

REMOVAL OF IRON

In heat exchange operations, where cooling water is involved, nothing is more important to effective, economical operation than clean, non-scaling, non-corrosive water. Whether your needs are small or large, the experience of INFILCO engineers and properly selected INFILCO equipment can solve your problem.

For partial softening and alkalinity reduction, removal of turbidity, suspended and organic matter, and iron, ACCELATOR® treating plants are widely used.

For softening, zeolite softeners may be used alone or in conjunction with "ACCELATOR" treating plants. Side stream continuous clarification can be handled by one of several types of filters. For pH adjustment, chemical feeding equipment is available.

Such equipment is giving superior service throughout industry—in gas and gasoline plants, refineries, public utilities and municipalities. It will pay you to investigate. Write for complete details.

INFILCO

The one company offering engineered equipment for all types of water and waste processing—coagulation, precipitation, sedimentation, flotation, filtration, ion exchange and biological treatment.

INFILCO INC. 911 South Campbell Ave., Tucson, Arizona
Field offices in principal cities in North America 5529

Circle 140 on READ-N-CIRCLE card for more data

If you're building, modernizing, expanding

New Low Voltage Circuit Breakers Offer New Safety, Economy

It will pay you to learn about these breakers. Somewhere in every electrical system there are circuit breakers for protection of electrical supply — and prevention of damage to property.

For better protection than ever — greater safety — more convenience, get the All-New Allis-Chalmers low voltage circuit breaker.

It is the only breaker that tells the maintenance man which phase is faulted — thus saving labor and downtime. A small signal flag does the trick.

These breakers can be furnished as basic units, in individual boxes, or several can be placed together in attractive cabinets.

In boxes or cabinets, these breakers offer the ultimate in safety to your personnel. No live parts are exposed — even when the front door is opened for maintenance and inspection.

As a result of these advantages, the new low voltage circuit breakers have met with unusual acceptance in the short time they have been available.

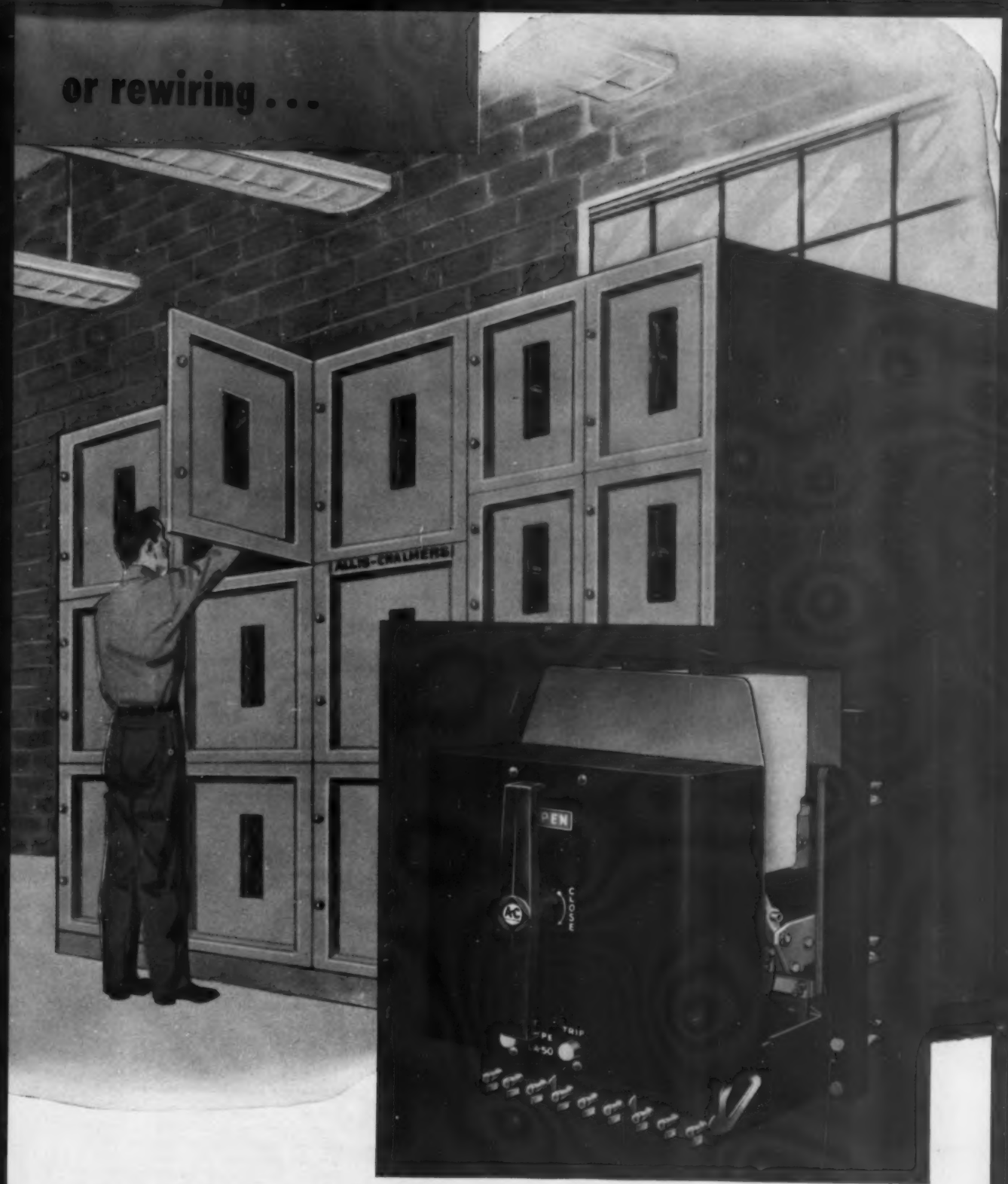
Get Complete Information—or let us send Bulletin 18B8252 to your electrician, purchasing man, or plant engineer. Call your nearby Allis-Chalmers office or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

A-4692

A-C ALLIS-CHALMERS

ALLIS-

Circle 111 on READ-N-CIRCLE card



CHALMERS

new bulletins

. . . just circle key numbers on READ-N-CIRCLE card on page 67

400-Tachometer troubles tamed

Condensed presentation of nine different types of tachometers including portable, permanent, centrifugal, chronometric, and vibrating-reed types are described in Bulletin 1048. Tachometers are available in both rpm and surface-speed types with ranges from 30 to 48,000 rpm and from 5 ft/min to 2400 ft/min. Four pages. HEFMAN H. STICHT COMPANY, INC.

401-Valves operate with explosives

Instantaneous operation of Conax explosive valves is described in detail in Catalog 5501-XV. Valves are actuated by firing a small, completely contained explosive squib. Illustrations and text describe operation of both normally closed and normally open valves. Also contains list of specifications and valve sizes. Four pages. CONAX CORPORATION.

402-Air cylinders provide push

Heavy-duty air cylinders that provide power for automation, materials handling, and boiler control positioning are described in this bulletin. Formulas and charts give air pressure, force, and volume required for operation. Specifications and engineering drawings are included for all five interchangeable mountings: foot, clevis, trunnion, blind end flange, and rod end flange. Twelve pages. PETCH MANUFACTURING CO.

403-Power-actuated controller

Tight closure, enduring accuracy, easy adjustment, low head loss, and long life are features of power-actuated rate-of-flow controller described in Bulletin 600-J9A. Contains installation diagrams and capacity tables for controllers from 4- to 30-inch diameter. Control system may be pneumatically, hydraulically, or electrically actuated. Four pages. BUILDERS-PROVIDENCE, INC.

404-Control with fluid power

Combination pneumatic-hydraulic valves and cylinders to augment automation in your plant are described in Bulletin CB. Standardized design, fully interchangeable mounting brackets, and the use of noncorrosive materials throughout are features of this equipment. Also included is complete list of accessories and description of packaged units. Four pages. MODERNAIR CORPORATION.

405-Metal grating data

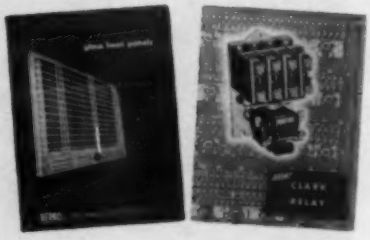
Uses of steel, aluminum, and stainless grating and stair treads are discussed in this bulletin. Lists safe load table with conversion factors. Gives data on standard widths and types of steel stair treads. Discusses bridge decking and suggested anchors for various grating installations. KLEMP METAL GRATING CORPORATION.

406-Insulate with glass fiber

Bulletin WPD-11 describes glass fiber blanket for thermal and acoustical insulation, sound absorption, vibration, and shock control. Tables show thermal conductivity, sound absorption characteristics, maximum workable temperatures, and shrinkage. Eight pages. L. O. F. GLASS FIBERS COMPANY.

407-Need automatic chlorination?

Operation and control of low-cost volumetric chlorine gas feeder with automatic safety features is described in Bulletin 840-L23B. "See-Thru" components permit inspection of entire chlorinizer operation. Typical flow diagram and installation photographs are included. Four pages. BUILDERS-PROVIDENCE, INC.



408-Glass panels provide heat

Electric radiant-heat panels in all sizes to provide clean, silent, safe, uniform, and economical heat are described in Bulletin GC-101. Heating element consists of a sheet of Pyrex glass with fused-on metallic electrically-conductive coating. Also includes information on both low-voltage and line-voltage control. Eight pages. BERKO ELECTRIC MFG. CORP.

409-Heavy-duty control relays

Bulletin PL7305-PM describes line of sectional-pole, heavy-duty, 10-ampere control relays available in models with from 2 to 12 poles. Relays can be mounted side-by-side with practically no clearance between them, with wiring run across their enclosed tops to reduce gutter requirements. Poles are independent units, that can be individually removed without disturbing other wiring. Eight pages. THE CLARK CONTROLLER COMPANY.

410-More light for less money

Bulletin MV-403 and 405 list 11 advantages of mercury vapor lamps in industrial plants, in outdoor areas, and in special situations. Contains tables including wattage and voltage required, lumens, lamp life, bulb size, burning position, fixtures, and other related facts on the proper use of mercury vapor lamps. Describes 16 different mercury vapor lamps, along with specifications and applications. Sixteen pages. SYLVANIA ELECTRIC PRODUCTS INC.

411-List colloidal lubricants

Applications listing 42 colloidal and semicolloidal dispersions for operational functions, maintenance, lubrication, and other industrial applications are included in Bulletin 2208. List includes dispersions of graphite, molybdenum disulfide, mica, vermiculite, zinc oxide, and acetylene black. Carriers and diluents, and physical properties are given for each product. Four pages. ACHESON COLLOIDS COMPANY.

412-Rotary pump eliminates seal

How stainless steel rotary pump handles corrosive solutions, abrasive slurries, and fluids without contamination is discussed in Bulletin VP561. Unique "flex-i-liner" principle eliminates need for stuffing boxes or shaft seals. Pumps are self-priming and do not require gaskets or check valves. VANTON PUMP & EQUIPMENT CORP.

413-Wire rope fittings data

Engineering data and charts for many types of wire rope and chain fittings are

contained in Bulletin 950-1. Includes complete information on dimensions and safety factors for links, shackles, swivels, hooks, turnbuckles, thimbles, sockets, ring bolts, and load binders. Eleven sections devoted to safety and strength of drop-forged fittings for wire rope and chain. Twenty-eight pages. THE THOMAS LAUGHLIN DIVISION, AMERICAN HOIST & DERRICK COMPANY.

414-Electric control cuts costs

Electric solenoid pilot control can cut costs of on-off regulation. Folder 1010 tells how Spence solenoid pilots open or close regulating valves when power fails. They can also be controlled by temperature, pressure, level, timing, and manual switches. Pilots can control steam, air, gases, and liquids in two- and three-way pilot combinations. Four pages. SPENCE ENGINEER COMPANY, INC.

415-Cable selection chart

Comprehensive selection chart for insulated electric cable included in Bulletin 1096. Lists minimum standard industry specification requirements for each insulation and covering. Describes trade name insulations, their limitations, and correct installation methods. Excellent reference for engineers concerned with purchase and use of electrical cable. Sixteen pages. THE OKONITE COMPANY.

416-Air conditioning history

Development of air-conditioning units from earliest attempts to present-day techniques are discussed in Booklet "Why RK?". Booklet compares three air-conditioning installations as to savings in initial and maintenance costs, on-the-site labor, materials, space, and year-round use. Diagrams show application of RK air-conditioning equipment in 12 different businesses. Excellent primer for basic understanding of air conditioning. Thirty-six pages. UNITED STATES AIR CONDITIONING CORPORATION.

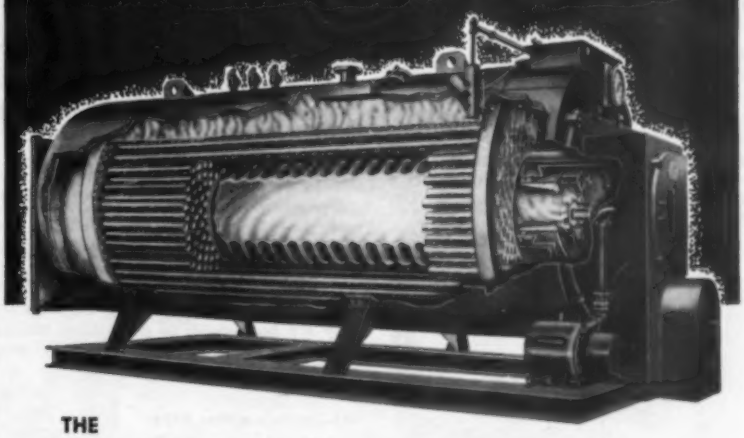
417-Airfoil fans reduce noise

Bulletin A-102 tells how efficiencies of above 92 percent can be obtained and noise level reduced by 65 percent with Airfoil fans. Airfoil blade design gives an even, smooth flow of air, eliminating eddy currents. Fans are ideal for forced and induced draft systems. They meet all requirements for commercial and industrial ventilating, air-conditioning, and heating applications. CHICAGO BLOWER CORPORATION.

418-Soft water simplified

Specifications for 17 water softeners and recommended operating procedure, design features, and schematic installation diagrams are included in Bulletin MSP-123. Operational aids include recommendations for water pressure regulators, water analysis, water meters, and corrosion control. Illustrations show simple connections necessary to fit softener into any water system. HAGAN CORPORATION.

GET YOUR
STEAM and HOT WATER
FROM A LOW COST PRODUCER!



THE
Continental AUTOMATIC BOILER

- generates the steam and hot water you need at low fuel cost and with little maintenance.
- is highly efficient—over 80% guaranteed—due to its unique "spinning gas technique".
- can be opened for cleaning or inspection by one man in less than ½ hour, for it has hinged doors at both ends.
- distributes heat evenly to the rear tube-sheet and all return tubes. This results in balanced water circulation and uniform longitudinal expansion of the entire pressure vessel.
- has long service life because of free, rapid water circulation, uniform heat transfer, simplicity of construction and quality workmanship.

Fully automatic, Continental Boilers are used for hot water and high or low pressure steam applications. Units range from 20 to 500 hp and can be gas, oil or combination fired.

Write for catalog and the name of your nearest distributor. Let us bid on the next boiler you need.

Send for all the facts on the Continental Automatic Boiler.

Continental
AUTOMATIC BOILERS
BOILER ENGINEERING
and Supply Company, Inc.
1 Manavon St. • PHOENIXVILLE, PA. • Phone 5832

Circle 104 on READ-N-CIRCLE card for more data

new bulletins

. . . starts on page 20

419-Industrial clothing guide

Bulletin describes complete line of lightweight, long-wearing, easy-to-clean Koroseal industrial clothing. Koroseal raincoats, suits, hats, aprons, and gloves are not affected by oil, grease, most acids, alkalies, and caustics. Excellent buying guide for selecting wear-resistant and acid-resistant industrial clothing. Twelve pages. INDUSTRIAL PRODUCTS DIVISION, THE B. F. GOODRICH COMPANY.

420-Pyrometer selection made easy

Portable pyrometers and thermometers for rugged service, readability, and sensitivity are discussed in this bulletin. Contains information on thermocouples, thermobulbs, extension arms, and accessories for portable surface pyrometers. Also includes description and data on air velocity meters. ILLINOIS TESTING LABORATORIES, INC.

421-How to measure water vapor

Measurement of water vapor in air and other gases is informatively discussed in Bulletin 224. Discusses gravimetric, dewpoint, and wet- and dry-bulb methods, as well as some less common and even experimental methods. An easy-to-understand discussion of moisture measurement, causes, and effects. Twelve pages. PITTSBURGH LECTRODRYER CORPORATION.

422-Maintenance manual for V-belts

Manual discusses the following topics: designing new drive, double matching, belt installation, tension importance, drive alignment, cleaning, and V-belt storage. Full-scale photographs show belts that failed due to oil deterioration, cover fabric rupture, slip burn, ply separation, ruptured cords, distorted belt, abrasion, and base cracking. Excellent manual for all power services engineers concerned with V-belt power transmission. Fourteen pages. INDUSTRIAL PRODUCTS DIV., THE B. F. GOODRICH CO.

423-Coatings control corrosion

Catalog 3i describes coating properties and includes suggestions for selecting protective coating and surface preparation prior to coating. Amercoat coatings provide corrosion protection for structural steel, tanks, piping, and ductwork, and also contains properties and uses of Amercoat tank linings. Four pages. THE AMERCOAT CORPORATION.

424-Scotch steamboilerplant data

Operating characteristics of gas, oil, and gas-oil-fired Steamboilerplants are discussed in Bulletin A-1041. Cutaway illustrations show internal heat flow for units from 12 to 125 horsepower. Units are ready to produce steam as soon as they are hooked up to electricity, steam, water, and fuel lines. Eight pages. ECLIPSE FUEL ENGINEERING CO.

425-Electric motor data

Comprehensive descriptions and cutaway views of complete line of electric motors are given in this bulletin. Information on open dripproof, enclosed, and explosion-proof electric motors—all conforming to the new NEMA standards—is included. Ten drawings and graphs give reader essential data on performance and application features. THE LOUIS ALLIS CO.

FREE COPIES

For free copies of these handbooks, bulletins, and catalogs just circle the key numbers on the READ-N-CIRCLE card on page 67.

426-Control transformer handbook

Illustrations and data on control transformers is given in Bulletin GED-2767. Contains ratings, dimensions, prices, weights, and wiring diagrams for each model. Special section is devoted to panel and machine tool voltage-regulation curves for transformer selection. Transformers come in sizes from 0.05 to 5.0 kva with choice of primary and secondary voltages. Thirty-two pages. GENERAL ELECTRIC COMPANY.

427-Asbestos safety clothing

Bulletin TX-3A describes asbestos safety apparel for protection against heat, flame, sparks, metal splashes, and similar hazards. Includes asbestos suits, helmets, aprons, leggings, overshoes, and gloves. Also available are asbestos safety curtains and fire-smothering blankets. Twelve pages. JOHNS-MANVILLE.

428-Overhead crane selection guide

Catalog 86 tells why "E"-type overhead traveling cranes are economical in industry for intermittent use or for jobs not requiring high-speed lifting and travel. Contains photographs of major components such as hoist mechanisms, drive assemblies, trolleys, and controls. Lists standard dimensions, clearances, and capacities for all sizes in easy-to-understand chart form. Eight pages. WHITING CORPORATION.

429-Motor-generator brush guide

General-purpose industrial motor and generator brushes are discussed in Bulletin CP-2694. Describes characteristics and operating behavior of the "National" N-4 brush. Six "in-service" reports describe trouble-free operation and optimum commutation under many service conditions. Graph compares commutating ability versus brush life of four typical brushes. Eight pages. NATIONAL CARBON COMPANY, DIVISION OF UNION CARBIDE AND CARBON CORPORATION.

430-Scanning and logging systems

How Trans-Scan-Log control systems eliminate drudgery of manual logging is explained in Bulletin 98268. Tells how compact intelligence center coordinates all related process data, enabling operator to visualize, evaluate, and act upon every processing irregularity as it occurs—without leaving front of the panel. Excellent bulletin for latest information on automation in power stations. Fourteen pages. TAYLOR INSTRUMENT COMPANIES.

432-Electronic variable-speed data

How to keep Reliance V*S Jr. Drives operating at peak efficiency is described in Bulletin H-2104. Tells how a preventive maintenance program can be initiated. Includes complete list of parts and prices. Complete kit of replacement parts and exchange panels is described. Four pages. RELIANCE ELECTRIC & ENGINEERING COMPANY.

433-LP Gas—the Cinderella fuel

Three-color booklet gives history, characteristics, production, transportation, and use of LP gas. Describes 25 industrial uses, plus many uses in chemistry, transportation, and utilities. Booklet stresses high heating value and economical transportation. Discusses how LP gas supplies its own pressure-feed to equipment in use. Eight pages. GULF OIL CORPORATION.

(more new bulletins on page 74)

"Look Into" the latest complete data on

FUSES

FOR EVERY PURPOSE

To help you solve confusing fuse problems, Economy Fuse & Mfg. Co. has just issued a convenient, pocket-size folder that tells you exactly the right fuse for practically any purpose. This handy folder illustrates and describes all the latest fuse developments and lists capacities, sizes, prices, etc. Electrical contractors, and commercial, industrial or domestic fuse users, can obtain copies from their electrical dealer or wholesaler. "For Fuse Economy Use Economy Fuses."

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FOR BOILERS

...A PLACE YOU CAN USE
EXPERIENCED ADVICE

The familiar process of softening "hard" water for make-up in low pressure boilers has undergone some interesting changes in recent years. In the first place, with the rapid development of ionXchange processes, several groups of completely-new resins have become available — to make water-softening more complete, more efficient, and more economical. In the second place, there are now several *different* "softening" processes available, each producing different dissolved compounds in the effluent, and each having its particular purposes and applications.

WE WERE AMONG THE FIRST
TO DEVELOP ION-EXCHANGERS

Finally, the mechanical design of the systems has undergone important changes, with the great increases in resin capacities and the various new materials now in use. Our experience with ionXchange starts with the year that practical resins were first introduced, and covers a wide variety of successful installations. *This experience is available to you to help improve your water-softening operations.* Just drop a line to . . .

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our readers write

. . . to industry & power

Thermo Refresher for PE's

Gentlemen:

I am now in the process of preparing for my New York State Professional Engineers Examination and have found your Thermodynamics Refresher course very helpful.

Please forward the final three installments.

William O. Gaudy
Plant Engineering Department
J. H. Williams & Co.
Buffalo, New York

Gentlemen:

Our company receives your magazine INDUSTRY & POWER and recently I ran across article IV of the Thermodynamics Refresher. I would like to obtain a complete set of reprints of the series for use in preparing for the Registered Professional Engineers Examination. Articles of this type which are written by recognized authorities in their field are most helpful in regrounding oneself in the basic principles. Your consideration will be appreciated.

Gordon C. Hellwig
Engineer
Flexonics Corporation
Elgin, Illinois

● INDUSTRY & POWER's *Thermodynamics Refresher was concluded in the November 1955 issue. Copies are available as described in "available reprints" on page 82 of this issue.*

Delays beyond our control

Gentlemen:

Sometime ago we returned information card requesting information No. 714 of the November 1955 issue concerning quicksetting aluminum putty manufactured by Chemical Development Corporation. To date we have not received this information.

T. M. Smith
Plant Engineer
Poinsett Lumber
and Manufacturing Company
Anderson, South Carolina

● *Delays in acknowledging requests we forward to manufacturers for readers often occur due to the large number of requests that come in.* INDUSTRY & POWER *forwards reader requests to the manufacturers promptly, but has no control over how soon the manufacturers acknowledge them.*

Out-of-print reprints

Gentlemen:

Recently we sent . . . our one remaining reprint from INDUSTRY & POWER, July 1952 issue, on "Combating Corrosion from Industrial Chemicals" by George Schaffer, and wonder if possibly you may have on hand additional copies of this that you can let us have.

This article aroused considerable interest on the part of both our agent and his principal customers, resulting in a request for a dozen or so additional copies for distribution to his most important clients. As a result, if you could let us have this number without inconvenience to yourself, it would be most appreciated by all parties concerned.

L. W. Gover
Export Department
Milton Roy Company
Philadelphia, Pennsylvania

● *Single reprints of articles and special reports as listed in our "available reprints" section (see page 82) are available without charge until supplies are exhausted. Tearsheets of all articles, whether or not reprinted, are available in single copies without charge from issues of the current and immediately preceeding calender year. Any articles dating beyond the immediately preceeding calendar year are available at $1.00 per single copy unless reprints still happen to be available. For quantity prices of out-of-print articles, write directly to our Reader Service Department.*

Caution before commitment

Gentlemen:

I want to compliment you on the editorial which appeared on page four of the November issue of your magazine.

The editorial discussed a subject which is of vital importance, not

only to the coal industry, but also to the oil and gas industry. ". . . caution before commitment" is an excellent phrase.

As a matter of interest, I am enclosing a copy of a resolution adopted by the Board of Directors of our Association. The subject with which you deal is one on which too little editorializing has been done. We are hopeful that in the public interest the facts will be fully developed and publicized concerning America's energy needs.

J. H. Cunningham
Director of Public Relations
National Coal Association
Washington, D. C.

● *In part, National Coal Association's resolution states: "The nation's best interests are not served by unwarranted optimism about the early availability of low-cost nuclear power." With this we agree. But when is optimism "unwarranted" and when is it "warranted?" We editorialize to some extent on this subject in "this month's comment" on page 33 of this issue.*

How to get INDUSTRY & POWER

Gentlemen:

Will you please furnish the writer with your monthly publication INDUSTRY & POWER.

J. E. Carlson
Chief Electrical Engineer
The Dow Chemical Company
Madison, Illinois

Gentlemen:

Your November issue has just crossed my desk, and as usual I've found several articles which are of sufficient interest for me to desire tearsheets of them. . . .

I'd also like to be included on your regular circulation list if this could be arranged.

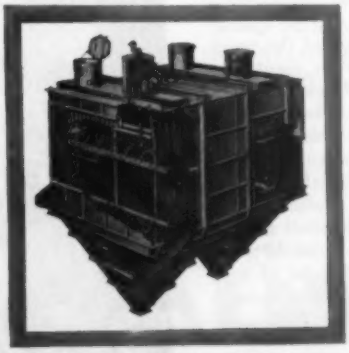
F. W. Brandt
Electrical Engineer
Ebasco Services Inc.
New York, New York

● *Requests to be placed on INDUSTRY & POWER's circulation list, such as these, are routed to our Circulation Department. Questionnaires then are sent to all candidates for our circulation list to determine whether or not their responsibilities correspond to those defined by our circulation policies. If the candidate qualifies and indicates a definite desire to receive INDUSTRY & POWER, he is placed on our circulation list without charge.*

Buell "LR" Fly Ash Collectors GUARANTEED for TOP EFFICIENCY

Buell Cyclone Collectors also deliver extra efficiency, due to exclusive shave-off design which harnesses backflow and puts it to work!

The Buell Guarantee of Efficiency which goes with every installation of an "LR" Fly Ash Collector is based on many years of successful field experience. The simplicity of design and proved efficiency of performance makes the "LR" ideal for low and high pressure boiler operations up to 2000 BHP with either natural or mechanical draft.



Buell "SF" Electric Precipitators with exclusive Spiralectrodes and Continuous Cycle Rapping have established brand new concepts in dust collection efficiency.

FREE BOOKLET!
"The Collection and Recovery of Industrial Dusts." Write to: Buell Engineering Company, Dept. 90-B 70 Pine Street, New York 5, N. Y.

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MECHANICAL ELECTRICAL

Experts at delivering Extra Efficiency in
DUST COLLECTION SYSTEMS

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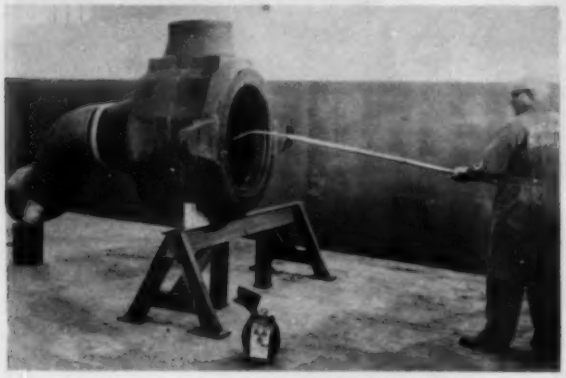
ideas in action

. . . for industry & power

Cobalt-60 tests welds

Cobalt-60 is being used successfully and economically to test welds in piping, valves, and large complicated alloy-steel castings in which walls as thick as 2½ inches are built up by welding, at the National Supply Company. Cobalt-60 provides a source of gamma rays equivalent to that of radium costing more than 30 times as much. It will lose half of its energy in 5.3 years (radium would take



4000 years), but it can be replaced several times at a small fraction of the cost of radium. The piece of cobalt-60 is about ⅛ inch square. A lead container with 4-inch walls holds it for transportation and storage. It is kept and used in a room with 18-inch thick concrete walls.

To facilitate handling, the cobalt is kept in a stainless steel capsule handled by a seven-foot-long aluminum rod with a releasable magnet on the end. Handlers are protected by an exposure badge, a dosimeter, a survey meter that checks radioactivity in the test area, frequent medical examinations, and supersafe scheduling of testing operations.

X-ray film is wrapped around the outside of the weld. Metal numbers are taped at several points for identification of film position and location of defects. Penetrometers, which consist of small pieces of steel (about two percent of the metal thickness) with two or three holes through them, are also taped on the metal near the welds to compare with possible dark spots that indicate defects. Film is covered with opaque paper as protection against visible light rays. The cobalt-60 is put in position to emit gamma rays through the weld for periods ranging from 20 minutes to 8 hours, depending upon the conditions of test. The method has proved more satisfactory than outside laboratory testing.

Air conditioning is almost for free

Cost of operating year-round air-conditioning system at Cowles Chemical Company's new Skaneateles Falls, N. Y., plant is almost negligible. In summer, system uses cold well water for warm weather cooling before using it as a cooling medium in production process. In winter, water is used for space heating after it has absorbed heat in manufacturing processes. Water comes from well at 50 F. Process effluent is 120 F. Trane Climate Changer air handling units serve most of office space. Individually controlled UniTrane units supply year-round air conditioning to instrument room, library, conference room, and individual offices.

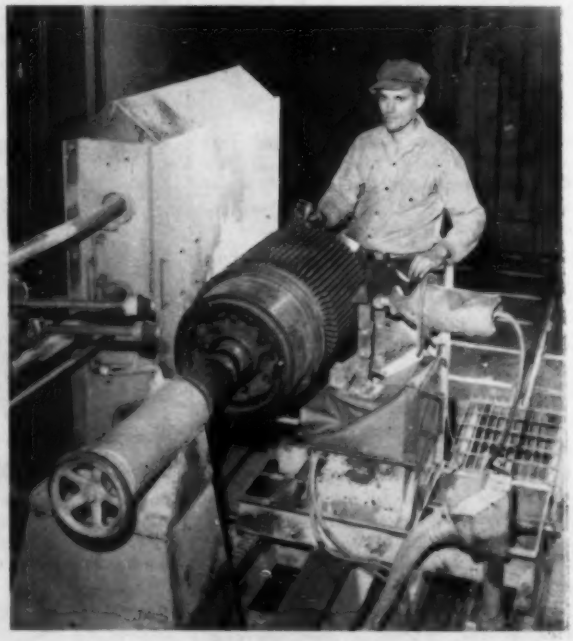
Fashion fibers filter air

Nonwoven felt of Dacron polyester fiber is now used for high draft ratio dust collection bags giving over 99 percent efficiency. They can handle from 6 to 100 times volume handled by most filter media now in use. Filter bags of Dacron collect flour, starch, fine chemicals; clean ash-laden gases; and filter air for delicate processing areas.

Orlon acrylic fiber dust bags collect highly abrasive materials such as byproducts from manufacture of insulating material.

Motor cleaning time reduced drastically

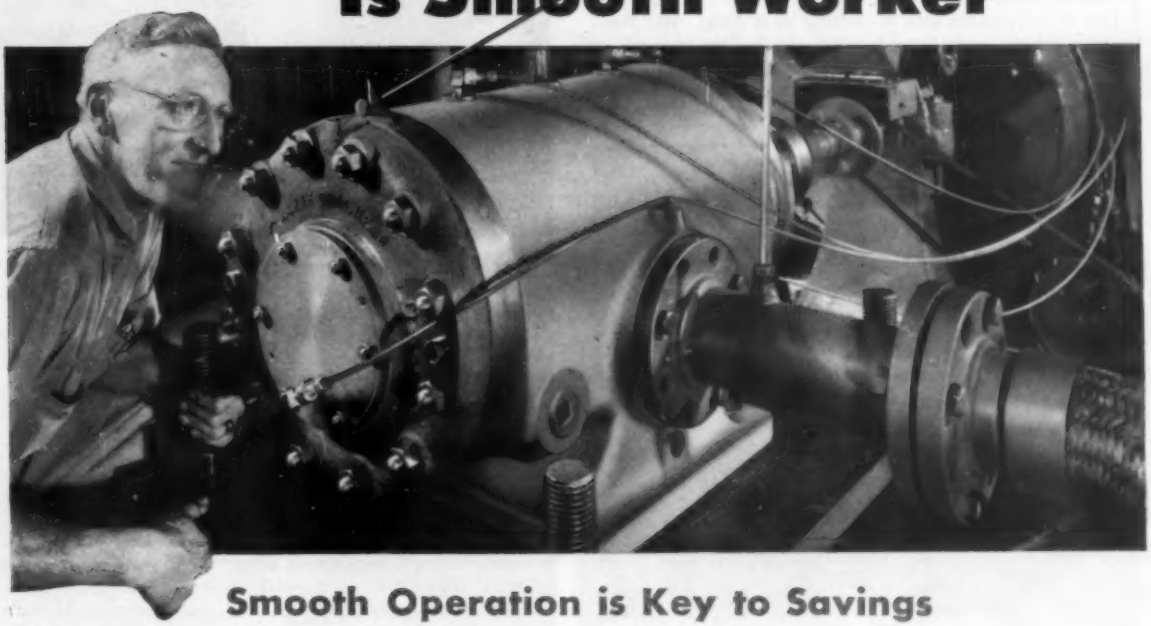
Motors and generators are cleaned, reconditioned, and rewound at Chicago, Rock Island, and Pacific Railroad's Silvis, Ill. shops in jig time. Motors are first cleaned. Large traction motor armatures are stripped to bare metal and cleaned in a special airblast room made by Pangborn Corporation. White silicia sand is blasted at armatures by two fixed nozzles from different angles.



Armatures are mounted on wheeled carriage and rotate automatically. Cleaning now takes 20 minutes compared with six to seven hours by wire-brush method previously

Coin Trick Proves

RO-FLO COMPRESSOR Is Smooth Worker



Smooth Operation is Key to Savings

Everybody around the place knew the *Ro-Flo* compressor was a smooth operator. But just how smooth?

Someone suggested the old coin trick . . . balance a coin on it while it's running.

The next we knew the foreman was calling, "Come down and see for yourself." We went to the shop. And sure enough, there the penny was standing as still as you please.

What does that mean to you?

It means, here's a compressor that needs practically no foundation. And it means there's no wear and tear from vibration...less maintenance.

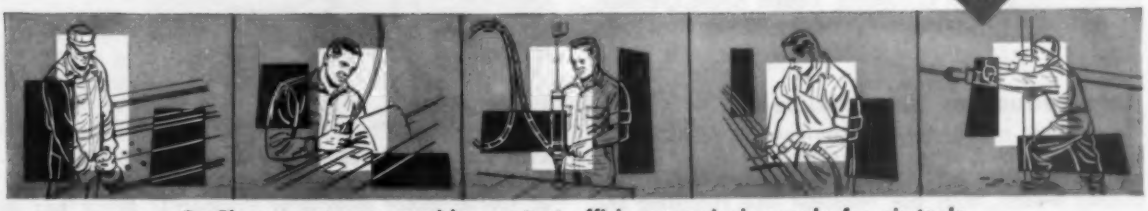
You get constant air supply with this machine, too. For this story: Call your nearby A-C office for complete information, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

A-4716

Ro-Flo is an Allis-Chalmers trademark.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS



***Ro-Flo* compressors provide constant efficiency and air supply for air tools**

Circle 108 on READ-N-CIRCLE card for more data

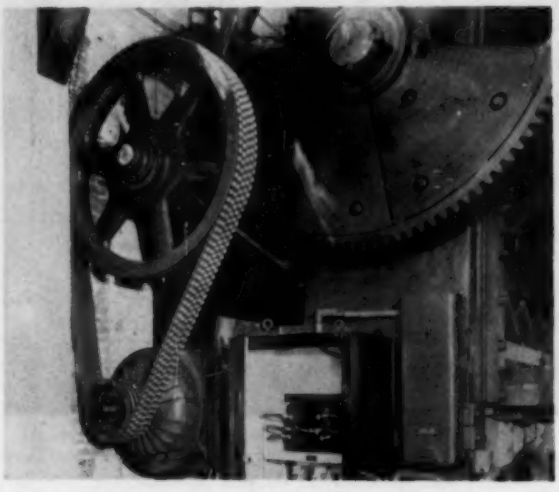
ideas in action

. . . starts on page 26

used. Motors and generators not stripped of wiring and other soft components are blasted with sawdust or corn cob grits in a separate room. Here, cleaning time has been reduced from 45 minutes to 5 minutes.

Adjustable V-belts simplify tension adjustments

Use of adjustable link V-belting does away with need to jack motor each time tension has to be applied on heavy machinery. Proper tension is maintained simply by adding or removing link. Belts are always perfectly matched. Vertically mounted motors can remain in set



position. Adjustable Brammer belts can be installed around any obstructions without having to partially dismantle equipment. One type of belt construction incorporates special studs for static-dissipating service. Users find that only four reels of various width belting need be stocked to service most requirements.

Refrigerant blows warning horns

New emergency warning horns are powered with liquefied Freon. Devices are independent of electrical or mechanical power that might fail in an emergency. In fire alarms, liquefied gas is confined under pressure in small containers with fusible plugs or release valves that allow it to vaporize when warning device is needed. Expanding gas is routed through a whistle to give an audible signal. Horns are available that give continuous blast of 95 to 100 decibels for 6 to 15 minutes. Falcon Alarm Company guarantees the UL approved units for 30 years.

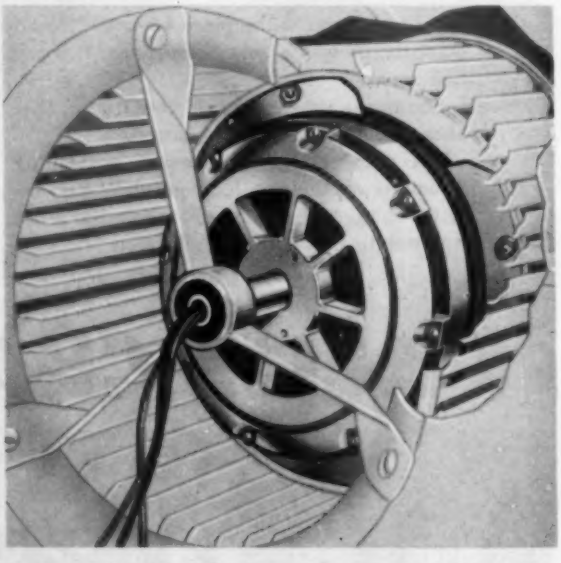
Data reduction time reduced

Advanced measurement technique, now in use at General Electric Company's jet engine plant near Cincinnati, cuts data reduction time to a fraction of that previously needed. With this magnetic tape recording and data reduction system, multiple channels of data such as stress, vibration, pressure, temperature, speed, and flow can be recorded simultaneously at a test site. Data may be steady in nature or may vary up to 30,000 cps. Total recall of data is made possible by magnetic tape storage. Subsequent reduction and analysis is done electronically.

Data reduction is performed in multiple channels. Presentation of data can be made by using function plotters, direct writing oscillographs, continuous recording in terms of instantaneous amplitude and frequency, or cathode ray oscilloscopes and oscillographs. Equipment's flexibility gives wide choice in study of many types of data.

Blowers have "inside-out" motors

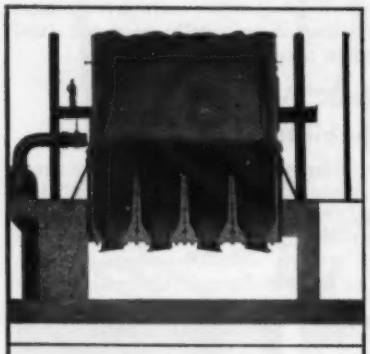
Even big centrifugal blowers will soon have new-type electric motors with rotating members on the outside. Blower, developed by Electronics Division of Iron Fireman Manufacturing Company, is integrally driven by a flange on rotor that connects directly to wheel. Rotor revolves around a stationary shaft and field coil assembly. Motor's



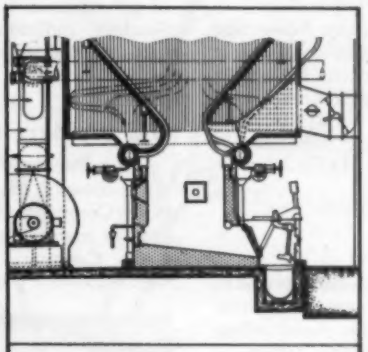
shaft and bearings also carry blower wheel. Motor becomes an integral part of wheel. Need for belts, pulleys, or special motor mounts is eliminated. Motor can be

ASHPIT REFRACTORY CASTABLES

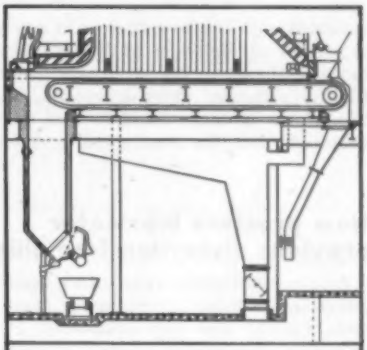
Rugged B&W Kaocretes Stand Up Under Abrasion and Erosion



Erosion, due to dry ash sliding down the hopper, is the big problem in this ashpit.

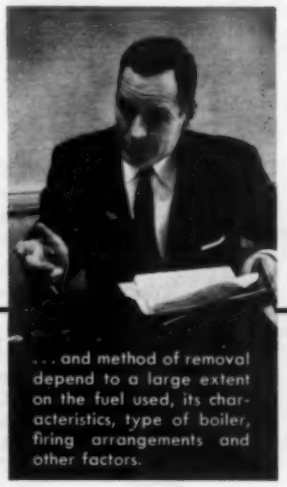


Water jets can cause abrasion of ashpit floor refractories, and water splattered on the walls may cause spalling.

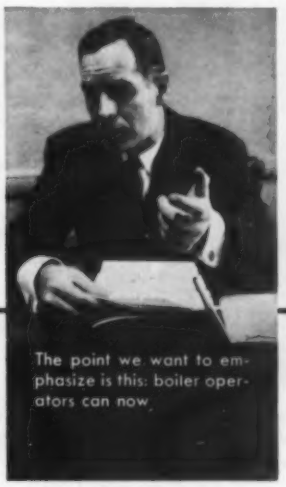


Continuous deposits of ash from a stoker-fired boiler have an abrasive effect on this ashpit lining.

These boilers are fairly typical of the problems we run into with ashpit refractories. Naturally, the ashpit design



. . . and method of removal depend to a large extent on the fuel used, its characteristics, type of boiler, firing arrangements and other factors.



The point we want to emphasize is this: boiler operators can now

. . . cut their refractories maintenance, in practically all ashpits, with the use of special refractory castables such as B&W Kaocrete A and D.

How B&W Refractory Castables Cut Ashpit Maintenance

When you consider the punishment ashpit refractories have to take, it's no wonder they are usually the most expensive item of refractories maintenance.

In almost all ashpits, they have to stand up under abrasion and erosion of the ash itself. If the ash is quenched in a water-filled hopper or with sprays, the hot ashpit walls may be splattered with water. The refractories must have spalling resistance to withstand this thermal shock. If the ash is removed by "raking out" or by high velocity water jets, the lining must be able to take this kind of abuse.

How do refractory castables stand up in this kind of service? Here's an example: A public utility made a trial installation of B&W Kaocrete in one of their ashpits. It gave over two years more maintenance-free service than the refractory previously used.

On the strength of this performance, another ashpit was lined with B&W Kaocrete—and this was a tough one. Two opposing high velocity sprays were used for quenching and ash removal. Water splattered on the ashpit walls, which meant the lining was subjected to severe thermal shock. In addition, the jets had an abrasive effect on the floor.

The service was superior to the refractories used before. As a result, this public utility is using B&W Kaocrete to line all ashpits.

These are examples of installation savings made possible by using refractory castables instead of brick. B&W Kaocrete D was specially developed to have unusually high resistance to abrasion, erosion and spalling—properties that are essential in ashpit service. For less severe operating conditions, B&W offers Kaocrete A, which will also give satisfactory service in many types of installations. Your local B&W Refractories Engineer will be glad to give you complete details on the performance of these B&W Refractory Castables.

THE BABCOCK & WILCOX CO.
Refractories Division
General Offices:
161 East 42nd St., New York 17, N. Y.
Works: Augusta, Ga.

a-899

Circle 136 on READ-N-CIRCLE card for more data

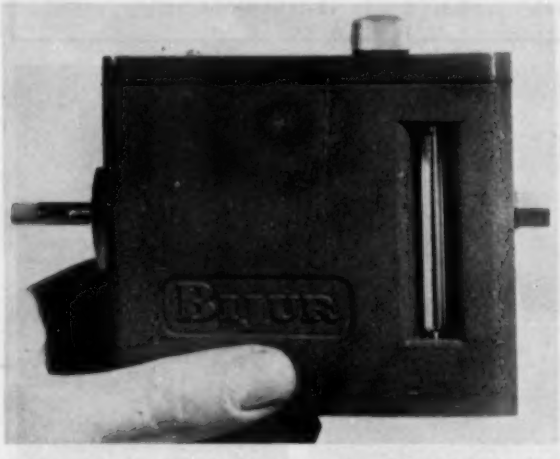
ideas in action

. . . starts on page 26

mounted with shaft vertical or in any position. Advantage is greater air delivery in relation to size, weight, power input, and cost of blower-motor combination. New ventilation principle gives increased efficiency and longer life. Motor is constructed so that it can be dynamically balanced, both for mechanical and electric unbalance.

New pressure lubricator provides distortion-free oiling

Automatic lubricator using new constant-pressure pump solves major problem for close tolerance machine tools, optical and test equipment. Periodic hand oiling or cyclic lubrication creates a rising-falling action of tableways and other precision bearings, destroying micro-



inch accuracy. Lubricator, made by Bijur Lubricating Corp., keeps a boundary film of oil at a constant pressure between precision parts, eliminating objectionable film variation. It also prevents excessive oil drips that result from high-volume flood lubrication.

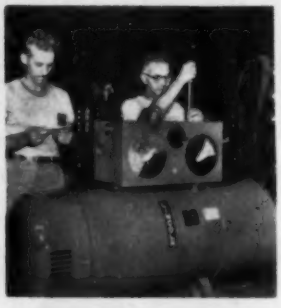
Pushbutton starters save time

Changeover from manual control to pushbutton remote control synchronous motor starters for six 440-volt ball mill grinder drive motors has increased plant efficiency

at The Diamond Portland Cement Company, Middle Branch, Ohio, and has eliminated false motor starts. Three separate operations were required to start and synchronize each drive motor. Synchronous motor starters, designed and built by The Electric Controller & Mfg. Company, give fully automatic motor control at the touch of a button on a control panel near each drive motor. Starters, individually housed in totally enclosed steel cabinets, are installed in a separate control room.

Old welders rehabilitated

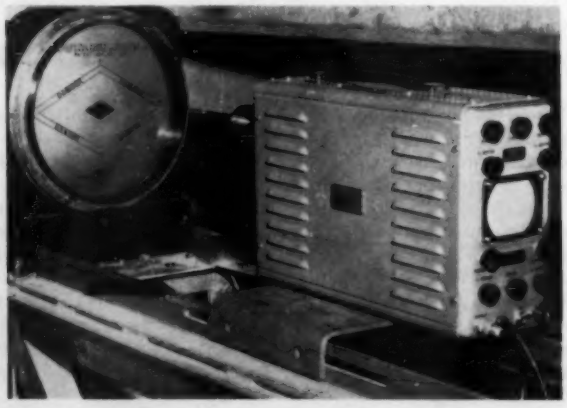
Old welders can be brought up to peak efficiency again quite cheaply. Many companies, such as Perfection Steel Body Company of Galion, Ohio, supplement normal preventive maintenance with a planned reconditioning program. Company will return six 300-ampere Lincoln welders every week to Lincoln Electric Company's Lin-



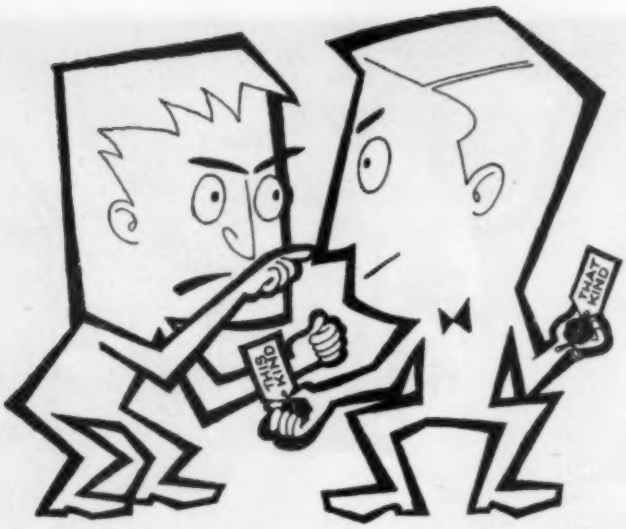
conditioning division until all their machines have been remanufactured. Machines will give another full service life. They carry standard new machine guarantees after going through remanufacturing production line. Cost is half that of a new machine.

TV safeguards giant forging press

Closed-circuit TV gives precise control of a huge forging press at the Aluminum Company of America's works in Cleveland, Ohio. Offcenter loading interferes with precision performance of the press and may even damage it. Du Mont closed-circuit TV system shows press oper-

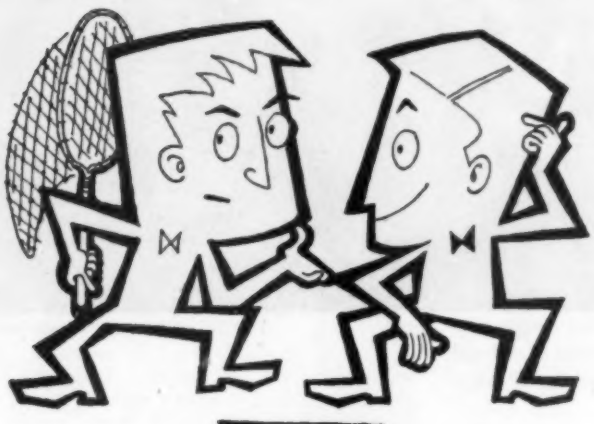


ator at all times whether press is centrally loaded and whether immediate corrective action is necessary. Camera photographs a deflection gage at press foundation and transmits picture to control panel which is out of visual range of gage.



What's the big idea buying several kinds of coal for our steam plants?

It's a good idea. The kind of coal that burns most economically in the old boilers isn't efficient for the new ones.



How do you know you're right?

Look at the coal bills. We are generating more steam at a lower fuel cost. You can tell from the ashes we are getting more complete combustion, and there's less clinkering.

Where did you get this idea, anyway?

From the C & O Coal Department. They convinced us that different types of burning equipment need different types of coal. From the high quality coal produced on the C & O, we selected the quality and size of coal that works best in our particular installations.

P.S.

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LEON SWIRBUL

Portrait by Fabian Bachrach

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LEON SWIRBUL, ***President, Grumman Aircraft Engineering Company***

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this month's comment - -

caution before commitment

Some months ago, November to be exact, we commented on the fact that industrial fuels is a subject of great debate. Last month, we reported in our Review and Forecast that industrial fuels was and would probably continue to be a domain of fierce competition. Close on the heels of these comments, we hear from the National Coal Association advising that "The nation's best interests are not served by unwarranted optimism about the early availability of low-cost nuclear power."

We are quite gratified, however, to note that in the sentences of its policy statement on atomic energy preceding this caution against unwarranted optimism, the National Coal Association says ". . . . there is need to continue government sponsorship of the development of nuclear energy. To this end, (we) recognize the need for the government to support national laboratories and to carry out the basic as well as applied research in the field of atomic energy." These quotations are taken from a policy statement which, in total, calmly recognizes that the coal industry is about to meet a new competitor. But this policy statement meets this prospect of new competition in its already highly competitive business without wholesale denunciation, across-the-board condemnation, or challenge on fabricated moral issues. This temperate attitude we applaud.

Now there remains the question: When is optimism warranted — or unwarranted? As in most situations vital to human beings, answers to such questions depend on vested interests of the observer. Certainly, we cannot expect the National Coal Association to eagerly seek out grounds for optimism about nuclear energy, with the zeal that some "nuclear" engineers might muster. All the more reason that we applaud the temperate attitudes of this spokesman of the coal industry.

Fact is that much technology bearing on the prospects for economic nuclear power are not yet known outside of certain security-bound circles. But when an established industry group spies a heavyweight competitor around the corner and calls out only against "unwarranted" optimism, we stand up to applaud. Especially when all this occurs in what has been, and still looks to us to be, a domain of fierce competition. Here we have indeed the kind of caution before commitment, pro or con, about which we first advised some months ago.

Harold A. Bergen

Editor

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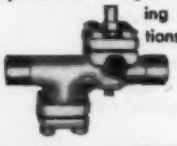

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Miniature control panel for No. 3 unit (at left) is only four feet long. Television receivers mounted above No. 2 panel show condition of fires at all times.

KARL C. P. MULLER

DON L. ASWELL

LEE MAURIN

As told to Donald Hartley
Associate Editor

Our authors were all recent graduates when they joined Louisiana Power & Light Company. Muller came from Louisiana Polytechnic Institute, Aswell and Maurin from Louisiana State University. Under station superintendent John R. Horton's guidance, they are pointing the way for all industry by their forward thinking and abandon of hide-bound practices.

Nearest thing yet to a COMPLETELY AUTOMATIC power station

ONLY FIVE men per shift are required to run Ninemile Point steam electric station, having total generating capacity of 325,000 kw. Fantastic? Yes, but true. This station, belonging to Louisiana Power & Light Company, is the Fantasyland of modern power stations. Even before the RCA and Dage television-monitored main gate opens by remote control from office or control room, you notice the garish colors with which this totally outdoor station is painted. Pastel pink turbines stand out vividly against the coral-color No. 3 steam generating unit and the two other equally distinctive boilers. Theory behind this color scheme is that each unit should retain its own individuality, and that color scheme should be healthily controversial. Newest unit, No. 3, is first to use colored porcelainized metal as an outer boiler skin. This eliminates corrosion and maintenance painting. All high-pressure steam line insulation is jacketed with aluminum for permanency.

Basic station research was started in 1949. Site was selected on basis of load requirements in this area, future load growth,

All three boilers look high because provision has been made below for coal firing, if required. Gate-monitoring TV cameras are hidden in office doorway.

availability of fuel and cooling water, and feasibility of transmission. Another advantage of this site is that river contour (station stands on a peninsula) makes debris pile up on opposite bank. Also, grade level is highest in this general area, eliminating some drainage headaches.

No. 1 boiler details

No. 1 unit went on the line in April, 1951. Boiler is a Combustion Engineering 650,000-lb/hr, 955-F at 1350-psi water-tube unit with primary and secondary superheaters, bypass and damper superheat control. It has a Combustion Engineering tubular-type air preheater and economizer. Firing aisle is arranged in three elevations with four burners on each. Burners are center-fired type DY-6 by Forney Engineering. They burn natural gas at a maximum pressure of 35 psi, but are equipped to burn medium diesel oil as emergency fuel. Diesel oil will not require any preheating.

Natural gas comes into the station at between 85 and 125 psi and is reduced to 52 (± ¼) psig at an elaborate regulator station. Continuous control of gas measurement is provided with all factors involved being recorded for future study.

Penn gas meter transmitter consists of a mercury U-tube manometer with a magnetic armature core float operating within two coils outside of the manometer tube. A similar core and pair of coils are in the receiver. No pressure-tight bearings are used that might cause friction at linkages. Transmitter is housed in a thermostatically controlled box. Automatic temperature and pressure compensation provides for any variance from design conditions.

Certified orifices are used so that station efficiency, so far as fuel is concerned, may be easily calculated at all times.

All three boilers are built at about a 30-foot elevation for future conversion to coal firing, if it should ever be required.

No. 2 boiler details

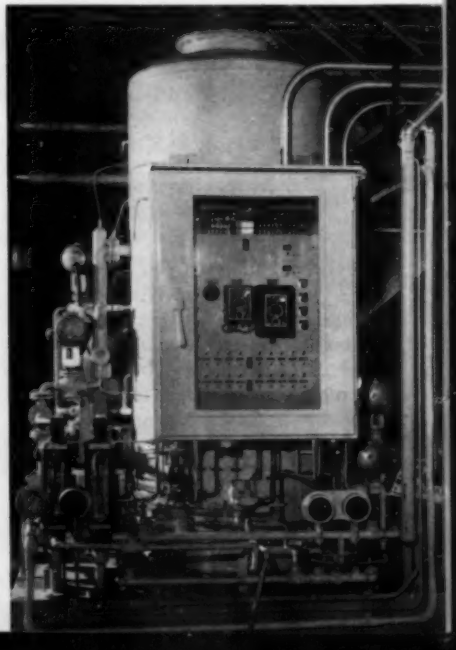
No. 2 unit is a Foster Wheeler 950,000-lb/hr, 1550-psig, 1005-F boiler. It has desuperheating condenser control with two Ljungstrom air preheaters and Green Fuel fans. This unit has 12 Forney natural gas burners on two elevations (again equipped for using medium diesel oil as emergency fuel). They are equipped for remote pneumatic operation from central control room. Boiler is equipped with Utiliscope furnace television—two cameras look into furnace and transmit to two receivers above control room panel. In this way, control room operator can inspect fires at all times. Some bugs are still to be ironed out of this system—pilot flame luminosity is not sufficient to be picked up by cameras. This unit is similar to No. 1, but it has one more feedwater heater (No. 1 has only four). It uses the first fully automatic demineralizer for power stations. This demineralizer is all pneumatically operated. Besides being clumsy, standby manual operating features are crude. Nevertheless, it has been so efficient that use of an evaporator has been completely eliminated.

Both No. 1 and No. 2 units have General Electric tandem-compound preferred-standard turbogenerators (60/66,000 kw and 90/99,000 kw respectively) with deaerating condensers. Deaerating condensers make possible use of condensate and boiler feed pumps in tandem. This simplifies feed pump design because suction pressure is high enough at all times to prevent cavitation. Pressure and electrical interlocks prevent development of low suction pressures.

Use pneumatic systems

First two units have pneumatic messenger control systems. Air is supplied by Nash wet centrifugal air compressors (60 cfm at 75 psig) and processed through an Industrol air dryer and Bailey air filters. Feedwater controls are by Bailey

Fully automatic, portable mixed-bed demineralizer services all three units.



and combustion controls are by Leeds & Northrup on both units.

No. 3 unit has a Riley reheat boiler with pressurized and water-cooled furnace—it was the first one in this so-called low-cost fuel area to be designed as a reheat unit. It is equipped with a superheater, Hays steam temperature control, economizer, and Ljungstrom air preheater. It has a porcelainized steel clad insulated setting. Boiler stands 149 feet high, with provision for future coal conversion if necessary.

Boiler has reheat

Boiler is rated one million lb/hr, 1550 psig at 1005 F, with reheat to 1005 F. It is equipped with 20 center-fired Peabody burners located on four elevations, all front firing. Burner throat tiles are Silmanite—which should last lifetime of the boiler. Four-inch burners are for 35-psig natural gas service, with capacities of 67,000 cu ft/hr, or 3800 lbs/hr of oil per burner. Burner tips are being redesigned for straight mechanical atomization of medium diesel oil. This will eliminate necessity of keeping oil heated and of using steam for atomization. Switchover to oil firing is manual. Burners are placed in or out of service from firing aisle. Combustion control, however, is done from control room.

No. 3 unit has electric register controls and electric pilot ignition. Furnace volume is 56,000 cu ft. Weight of water up to working level is 275,420 pounds. Control of superheat and reheat temperatures is done with dampers. For emergencies, boiler has spray injection of boiler feedwater in crossover between primary and secondary superheaters and at inlet to primary reheat tubes.

Fans are enclosed

Forced draft is supplied by American Blower HS fans housed in two concrete block structures. This reduces noise level around station. Air going into each fan house passes through perforated aluminum acoustic baffles. Forced air draft to No. 3 is measured by a venturi built into the air duct under the boiler. Boiler trim includes Foster safety valves and Hays feedwater regulators with three-element control. Fuel combustion is controlled through fuel/air ratio, based on oxygen content. Combustion control and instrumentation, including a paramagnetic oxygen analyzer, is by Hays. All superheat and reheat tubes have been equipped with thermocouples. These can be selected at random for placing on a scanner to give operators full information on tube temperatures.

On this boiler there are no welding rings in any tubes — they were all positioned and welded instead. There are no handhole plates. Tubes are secured to headers and drums by welding. No rolled joints were used. Safety valves are welded to headers and drums. Experience has shown this is the best way of preventing leaks. Maintenance, of course, will involve cutting and rewelding.

Uses only one gage glass

Boiler has only one gage glass on drum end — a result of recent ASME boiler code revisions. On each end of the drum are one manometric indicator and one float-type indicator. One manometric indicator is located outside control room window; other is fed to boiler gage panel. Two float-type indicators transmit to control panel. All pumps on No. 3 unit (except boiler feed pumps) have mechanical seals to eliminate gland leakage and maintenance packing. Boiler feed pumps have throttle bushings that serve the same purpose.

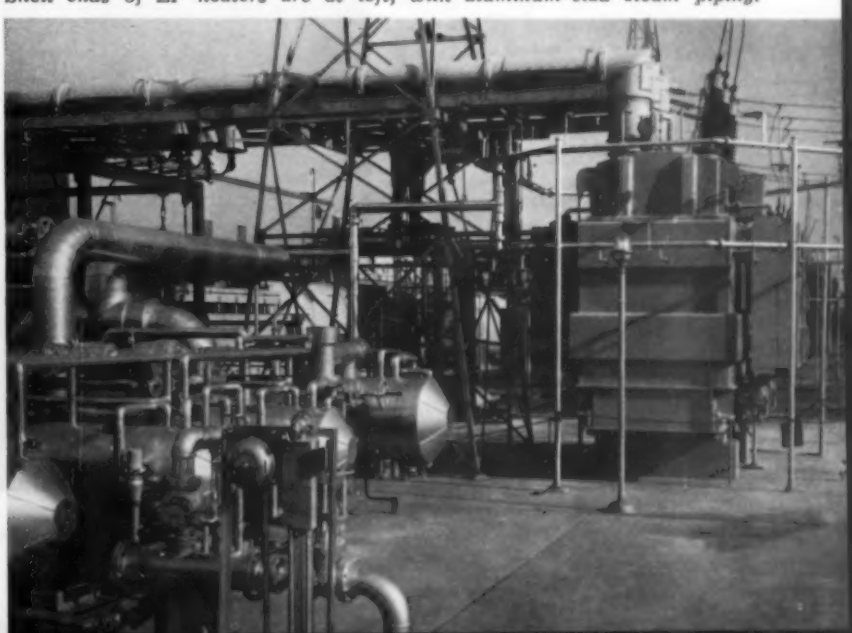
A centralized control room houses all instruments and controls for entire plant. Main control boards for first two units are eight feet long, of functional design, and the benchboard type. Indicating instruments are at the front and recorders mounted are at the rear. All instruments use readings from electric or pneumatic transducers of meters throughout plant. This eliminates danger of having high-pressure and temperature lines in control room. Initial installation costs would be higher, otherwise, too.

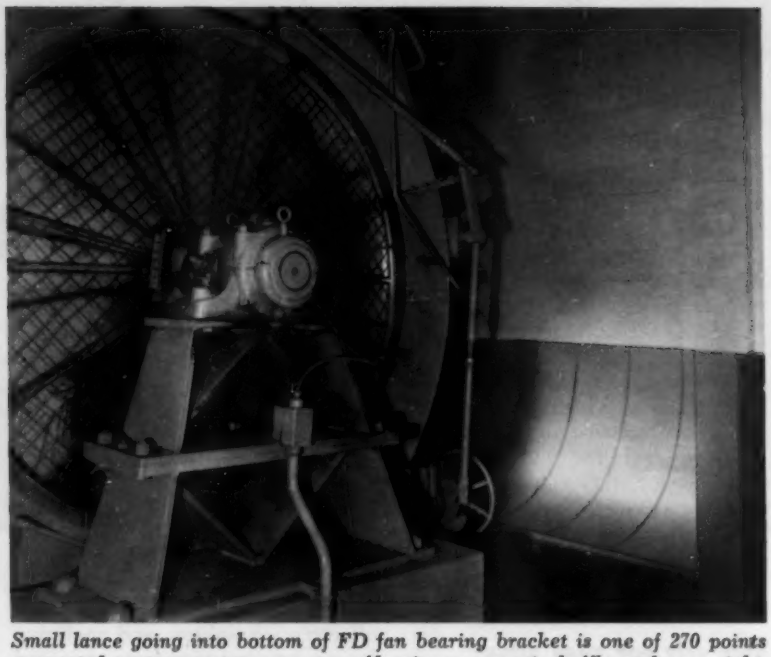
Control room operators are also responsible for control of the 115-kv transmission substation. A transmission control board has control switches for thirteen 115-kv oil circuit breakers, and metering for six transmission lines mounted on its face. Behind it is the relaying for all transmission lines and carrier sets for differential relaying of transmission lines (Westinghouse HKB relaying).

Has miniature control panel

When No. 3 unit was designed, a small four-foot long benchboard control panel was developed — using new, small, heavy-duty Mossman-type toggle switches and miniature instruments. One operator

Sprinkler system for No. 3 unit main transformer uses two full rings of nozzles. Shell ends of LP heaters are at left, with aluminum-clad steam piping.





Small lance going into bottom of FD fan bearing bracket is one of 270 points connected to temperature scanner. Aluminum acoustic baffle at lower right.

seated in a comfortable chair easily can see any instrument or reach any switch on panel. Most equipment on this miniature board can be pulled out from the front for easy maintenance. Graphic-panel design was omitted because experience has shown it does not help in good plant operation. Reheat boiler design involved additional instrumentation and controls.

On this small board, made by Hays, all control switches for normal nonautomatic operation are located in a one-foot section at the lower left-hand corner. When next unit is added, its board will be a mirror image of this one. All switches for normal nonautomatic operation of two units then will be in a two-foot space.

Operators work by touch

Control room operators are trained to operate switches while actually observing instruments. Thus, they can provide rapid corrective action for any system upset. Four-foot panelboard costs less and is easier to operate than would be a panelboard of more conventional design.

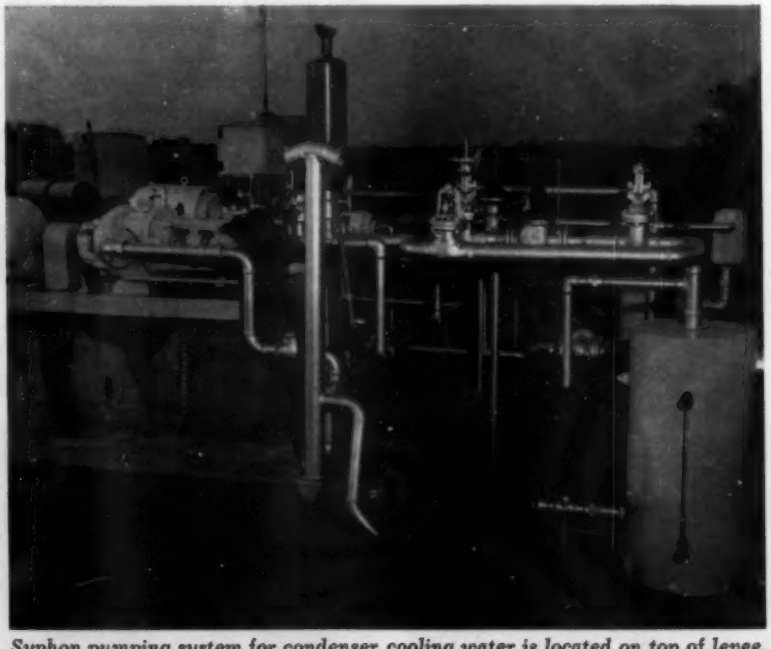
Use of new all-electric instruments and controls was investigated because of difficulties experienced with continuously operating instrument air drying and cleaning equipment. High installation costs, high compressor operating costs, and necessity of long transmission lines with a centralized control room also favored an all-electric system. Meters and indicators for No. 3 unit are electric except for seven miniature pneumatic recorders located on main board. No electrical or electronic miniature recorders were available when this board was designed. Indicating instruments are miniature milliammeters or voltmeters.

This type is reliable

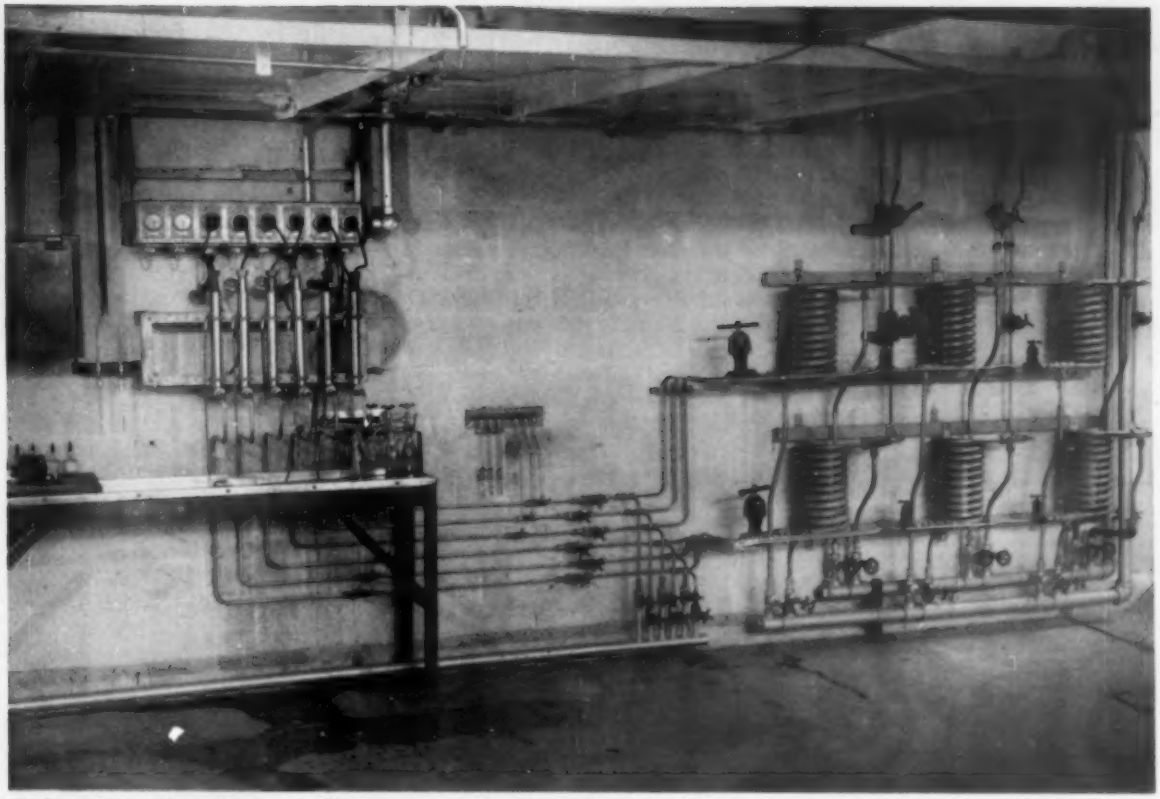
Sensitive galvanometer-type instrument has proved to be reliable and accurate. Manning, Maxwell, and Moore Company's Microsen pressure and temperature transmitters are used in conjunction with indicators.

A Minneapolis-Honeywell 270-point double-range scanner, using Chromel-Alumel and Copper-Constantan thermocouples, has replaced all other temperature recording instruments. This requires less overall maintenance and saves control room space. A 36-point pressure scanner was also installed to scan pressures, sound pressure alarm, and keep a continuous record. On all scanning equipment, permanent record readings are taken periodically by operating one switch.

Some temperature scanner difficulties occurred after installation, including stray dc interference from electric welding that was be-



Syphon pumping system for condenser cooling water is located on top of levee, outside plant, but, like other units, it has a common intercom connection.



Cooling coils and conductivity cells for water testing, centralized outside laboratory, are proving convenient, accurate.

ing done near scanner switching cabinets. Dust and moisture collected in remote switching cabinets. Calibration of potentiometer-type recorder shifted because of improper shielding of lead wires. There were some mechanical failures. All of these either have been or are presently being corrected by proper shielding, filters, and by use of electrically heated and pressurized switching cabinets. Feedwater flow nozzle for No. 3 unit was checked by "weighed water" test at Ohio State University. Coefficient of discharge was calculated and found to be 1.5 percent higher than measured value.

Each boiler is equipped with instruments that automatically shut off fuel should air flow or fans stop, furnace pressure be excessive, or gas pressure drop so low that burner ignition might be lost.

Demineralizer automatic

Perhaps most extensive application of instrumentation and controls involves a completely automatic mixed-bed demineralizer that supplies makeup water for all three boilers. Flowmeters, temperature elements, conductivity indicator-controllers and recorders, flow controls, level controllers, and timers monitor and control continuous operation of demineralizer through its service, exhaustion, and regeneration cycle.

Choose package type

Demineralizer built earlier for No. 2 boiler had proved so successful that it was decided to go to fully automatic type again. But this time, a factory-assembled package unit was chosen. Thus, unit would be smaller and could be tested before shipment from manufacturer's plant. Makeup through this demineralizer for all three boilers is normally about 18,000 gpd. Unit is regenerated once a day using old unit originally built for No. 2 boiler as a standby. Raw water is purchased from the city with normal sanitation chlorination.

This "package" Illco-way demineralizer reduces silica to less than .02 ppm and total solids to less than .1 ppm (which is better than an evaporator would give). The pH runs about 6.8 to 7.0. Regeneration takes about 3½ hours. Present planning incorporates use of a magnetic tape recording that will give a running commentary during regeneration cycle. Operators will have both an audible and visual indication of regeneration stage at any time.

Pumps across levee

Another unusual feature about this plant is that condenser cooling water circulating pumps are situated across the levee. Water has to be pumped over levee, through condensers, and then back over levee. This presented a problem. Only a smattering of information was available about maintaining the syphon-like action on discharge section because of air liberation caused by heating of circulating water in condensers. Problem was tackled by pumping off air at six- or eight-foot intervals on discharge line, but discharge pressure on circulating water pumps (less than

five psi) was so low that pumps cavitated. Problem was overcome by using different impellers. Practice has eliminated one circulator without reducing quantity of water circulated.

No. 3 unit uses booster pumps for service water (strained river water). This has eliminated installation of a fourth deep well pump. This was decided upon when operating experience with installed deep wells indicated a drop in water table.

A Nash vacuum pump is being tested on No. 3 unit to eliminate use of a steam-jet air ejector. Present tests indicate complete reliability.

Inner cooled generator

No. 3 unit has a hydrogen inner-cooled Westinghouse turbogenerator rated at 156,250 kw and 183,824 kva with 2910 field amps. Excitation is by a shaft-driven exciter. Only a main exciter is used — there is no pilot exciter — because of the Magamp excitation system employed. Possibility of using rectifier-type excitation was considered, but was rejected by manufacturers on basis of insufficient experience in rectifiers of sufficient size for this generator. Power leads from main generator to transformer are enclosed in I-T-E enclosed isolated-phase bus duct. Main station transformer is a Pennsylvania Class FOA transformer rated 18/115 kv and 175,000 kva.

Another unusual arrangement is installation of a hydrogen high-pressure system that is remote from the generator and is low-pressure manifolded to all generators. This system eliminates danger of explosion. In fact, whole station has been laid out with such respect for accident prevention that insurance rates are at a minimum.

No generator breaker is used on this unit — at generated voltage a full capacity motor-operated disconnect switch in parallel with a part-capacity synchronizing oil circuit breaker is used. Control wiring is mostly multiconductor 16 AWG cable, required by use of the miniature control panel.

Reheat turbine has many interlocks. If reheat flow stops, as shown by auxiliary switches of reheat stop valves and interceptor valves, turbine stop valve will close immediately. If exhaust shell temperature rises to 248 F, it closes turbine stop valve. If turbine stop valve closes while unit is on line, unit lockout relay is energized after one minute, shutting down entire unit. Beside this interlock, lockout relay is energized by unit differential relays (protecting generator and main transformer), by auxiliary transformer differential relays, by loss of field relay, and by negative sequence relay (to protect against phase unbalance in generator). Interlocks trip the burner gas-stop valve under any of these conditions:

- ¶ Trip of both FD fan breakers
- ¶ Low burner header gas pressure (set at one psig)
- ¶ Low pressure differential between wind box and furnace (set to trip at .025 in. wg)
- ¶ Closure of turbines stop valve if unit is on line
- ¶ Motoring of turbine for over one minute, as shown by position of no-load switches on governor servo-motors.

No. 3 unit has a circulating system similar to No. 1 and No. 2. However, its tailrace is designed not to produce added head to system.

Detect leaks easily

Main condensing unit, like all such units, is difficult to check for exact location of tube leaks with commonly accepted practice of belling tube inlet ends and leaving outlet ends to protrude. For this unit, however, tubes on both inlet and outlet ends were machined flush with tube sheet, making it possible to hang a thin membrane (covering quite a few tubes) over both ends of tubes. Tube leakage is then indicated by rupturing of membrane at defective tube because of vacuum pull.

Experience has shown that tube leakage occurs in high pressure heaters between tube and tube sheet, so high pressure heaters on No. 3 unit tubes were rolled for positioning only, and were then welded to sheet. It is also difficult to maintain a tight joint in internal water box joints. All internal water box joints were, therefore, welded instead of gasketed and bolted. Only exception was tube sheet, which was bolted to heater shell internally.

All station auxiliaries are driven by electric motors. No. 1 unit uses Allis-Chalmers motors, No. 2 uses General Electric motors, and No. 3 uses Elliott motors.

A central testing laboratory is located beneath control room so that all water samples can be fed into it. Besides eliminating walking around plant for samples, this system reduces CO_2 and oxygen pick-up. Controller conductivity cell for recording water purity is outside laboratory, so fresh samples are always available for testing. Normal water analyses are run by plant operators. Precision testing is done by testing department in laboratory once a day with extremely high-precision analytic equipment of the latest design.

Chemical feed centralized

Chemical feed system for all three units is in one central location. Sodium sulfide is added to water leaving condenser by a Milton Roy chemical feed pump. Boiler drum water is treated with phosphate by a similar system. Batch tanks for preparing solutions are stainless steel. Agitation from mixing water is sufficient to dissolve chemicals that have been weighed out previously and suspended in tank in a basket.

Instrument maintenance shops are located next door to laboratory, so that only one air conditioning system is required for control room, laboratory, instrument and electric maintenance shops.

Ebasco Services is responsible for design, construction, and start up of all units. Plant engineers have participated with Ebasco in testing all equipment for meeting guarantee specifications.

Crew is small

Ninemile station employs a total of 51 people from station superintendent to janitor. Five men on each shift actually operate the station. Goal of instrumentation and controls at Ninemile Point is a completely automatic, self-monitoring, steam generating power plant that requires only occasional maintenance. Once startup bugs are removed, this station may be as close to that goal as is possible at the present state of power station technological development.

What you should know about

STATIC ELECTRICITY

ROBIN BEACH
Consulting Engineer

STATIC ELECTRICITY accounts for fire and explosion losses totaling several hundred million dollars annually. Because of the war it wages on industry, static electricity has been called a killer, an arsonist, and a despoiler. Virtually no segment of industry is immune to electrostatic hazards.

This situation results from industry's accelerated operations, higher speeds, and use of more critical and vulnerable raw products. Powerhouse fuel, for example, was mainly lump coal at one time. It is more likely, today, to be pulverized coal, fuel oil, or gas. These modern fuels have much lower ignition thresholds than lump coal. They are especially susceptible to ignition by electrostatic sparks.

As an arsonist, static electricity is a dreaded character. Its sparks ignite flammable mixtures of liquid vapors and of gases when combined in explosive proportions with air. Flammable mixtures involving hydrocarbons enter an "explosive range" when they comprise about one to eight percent (by volume) vapor in air.

How is static electricity generated? How does its high, spark-inducing potential come into being? Many factors cause static electricity, influence its accumulation, determine its sparking potential and ignition energy, and control the starting of fire or explosion.

How static charge is generated

Contact between two dissimilar substances forces readjustment of molecular and atomic forces at the touching, or interfacial surfaces. Because of this, electrons migrate from one substance to the other at each molecular contact point. Substance to which the electrons pass becomes negatively charged. By losing electrons from its previously neutral atoms, the other substance acquires an equal positive charge. This acquisition of opposite charges establishes a voltage difference between the two substances. This phenomenon is known as the "contact difference of potential theory."

Lightning is one of nature's greatest forces. Man attempts to duplicate its force in laboratories to gain information on control of these high voltages.

Static electric charge is variable

Electric charge imparted to the two contacting substances depends on physical properties such as temperature, surface pressure, degree of contamination of interfacial surface layers, microscopic surface roughness, crystalline or amorphous texture and hygroscopic character of surfaces, molecular affinity for condensed water vapor or for absorbed gases, dielectric characteristics relating to insulating qualities, and dielectric constants. Dielectric constants may be explained as being a measure of the "ease with which an electron can be displaced within an insulator" under an applied electrostatic force.

Electric charge developed by placing in contact two crystalline substances whose surfaces are thoroughly clean and of optical flatness is, strangely enough, independent of pressure. Electrification developed is equal to the product of a physical constant, C (called Coehn's constant) and difference of the dielectric constants K_1 and K_2 of the two substances.

Coehn's equation for electric charge, Q, is

$$Q_{1\text{-}2} = C(K_1 - K_2)$$

Contacting substance having greatest dielectric constant becomes positively charged. Dielectric constants of various types of rubber range principally between two and three. Metals, for the most part,

have values within the range two to five. Hence, rubber with a dielectric constant of about 2.1 (as in a coal conveyor belt) in contact with steel rolls of dielectric constant 3.1 becomes negatively electrified because its dielectric constant is substantially lower.

Friction, as such, does not in general influence magnitude of charge developed between two substances in contact. By rubbing together fibrous materials, however, more points of contact are created. Thus, charges may become correspondingly greater. No amount of friction will increase charge on nonfibrous, hard-surfaced materials such as belts.

Static charges vary with material

Industrial materials do not remotely approach being optically flat. For this reason, electric charge developed by crystalline substances in contact increases appreciably with pressure. This is caused by microscopic roughnesses at the interfacial surfaces being gradually pressed into contact with each other. More electrons, therefore, can pass from substance of higher dielectric constant to the one of lower dielectric constant.

Two substances in contact generally have a potential difference of less than one volt. Most frequently it is in the order of millivolts or less. If one substance is an insulator, the electrons cannot move along its surface with freedom. Consequently, most of the charges are trapped on the two substances when they are separated, thereby retaining most of their acquired electrification. Speed with which two contacting substances are separated may materially influence the magnitude of the charge retained by each, retained charge being higher for more rapid separation.

During separation of two conductor substances that are in contact, all electrons readily flow at the last contact point back into the positively charged member from which they came. Although the two conducting substances possess a contact potential difference while in contact, they retain no measurable charge and voltage when they are separated.

High voltages come into being after separation of two insulators, or of one insulator and one conductor. While these substances are in so-called actual contact, they can be no closer to each other than that of an atomic diameter—a distance about one one-hundred-millionth of a centimeter, that is, 10^{-8} cm. Assume contact potential difference in this instance to be one millivolt. Voltage will vary linearly with separation up to start of charge leakage. If surfaces are separated a distance of three orders of magnitude (that is, 1000 times), voltage is also increased by 1000. Potential difference thereby becomes one volt. In this case, electrified surfaces are still only 10^{-5} cm apart. This separation distance is so small that it barely falls within the resolving power of a high-power microscope. If the two electrified substances are moved apart to one-centimeter separation, voltage theoretically becomes 100,000 volts. For a separation of ten centimeters, voltage would be 1 million volts.

Voltages of this high order are not commonly obtainable. Presence of such ultra-high electric forces stress air molecules between the separated electrified substances to the point of splitting air molecules into positively and negatively charged components called ions. To cause ionization of air under normal atmospheric conditions, a potential difference across one centimeter of air must be about 31,000 volts. This voltage is called the normal ionizing potential gradient of air. Positive ions are attracted to and neutralize some negative charges on the negatively charged substance. Positively charged substance attracts negative ions of the intervening air. This process is called neutralization by ionization. Because of this effect, voltage between the highly electrified substances diminishes through neutralization of a large number of such pairs of electric charges.

Retention of electric charges by two electrified substances, barring partial neutralization by ionization as explained above, depends on the degree of insulation existing between substances. That is, it depends on the dielectric property of the intervening air or other gas, liquid, or solid dielectric.

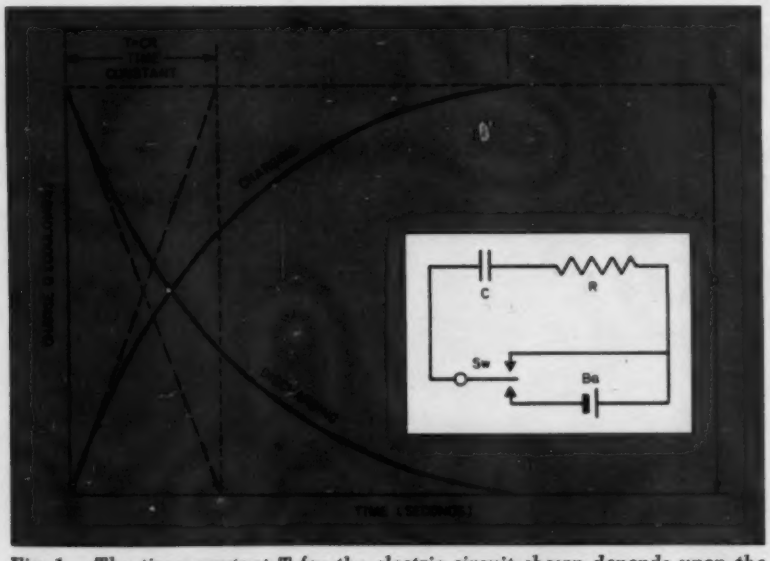


Fig. 1 — The time constant T for the electric circuit shown depends upon the values of C and R. Value of T is identical for charging or discharging.

Capacitor effects raise voltage

Clearly, accumulation of electric charges on two contacting substances — say a rubber belt with a steel roll — can lead to spark discharge (Fig. 2). Such a spark in its formation and occurrence simulates, in miniature, a natural lightning stroke. Storage of electric charges on extensive insulated areas of conductive materials — such as metal roofs or storage tanks — is particularly hazardous. Low resistance of such materials permits almost instantaneous discharge of all electro-

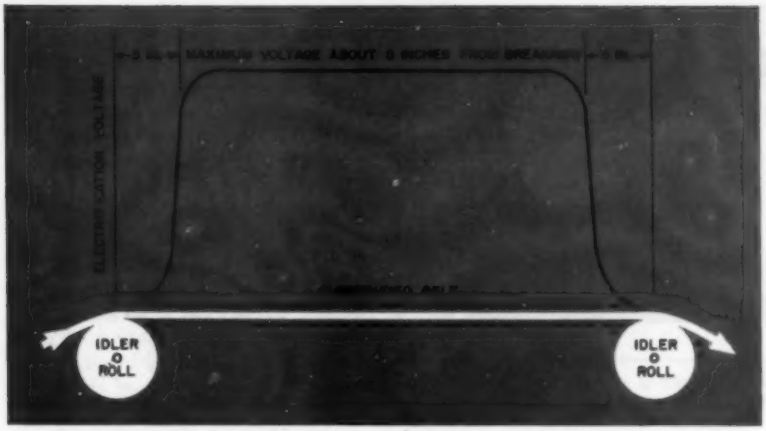


Fig. 2—Rapid voltage rise starting at left idler roll results from rapid decrease in capacitor effect between roll and retreating ions on moving belt.

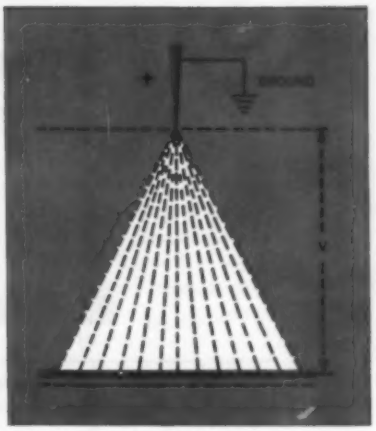


Fig. 3—Electric field converges from charged plate to grounded needle tip.

static energy accumulation after a spark has been initiated.

Systems that store electric charges in the form of energy can be considered condensers or "capacitors." When positive and negative capacitor plates are metallic, discharge by spark may be practically instantaneous, as explained above. But if discharge occurs through a very high resistance path, it will be slowed appreciably. It may require seconds, minutes, or even hours. In such instances, discharge will occur harmlessly as current leakage rather than as a spark.

Belt is capacitor plate

A rubber belt, again to use this simple example, may constitute one plate of a capacitor. The grounded steel pulley would comprise the other plate. The rubber belt is quite likely to have extremely high resistance. When electrified, it might be concluded from the above explanations that discharge would be retarded. But there are other conditions that may influence resistance of the discharge path and greatly reduce it. Ionization of ambient air is one example.

Time required to charge or discharge a capacitor system is frequently of critical importance in providing safety from fire and explosion hazards of electrostatic discharges. Time taken by a capacitor to charge or to discharge energy is dependent on value of its capacitance and on resistance of the path through which charge must pass in charging or discharging. This period of time may be expressed by the relationship

$$T = CR \text{ seconds}$$

where T = time constant in seconds
C = condenser capacitance in farads
R = resistance of electric circuit in ohms.

Physical significance of this time constant, T, shown in Fig. 1 is that 63 percent of the total change is made in the time T. If the change were to continue at the *rate* it started, the *total* change would be made in the time T.

Suppose a voltage capable of ionizing air is impressed across, say, a one-centimeter gap between two parallel plates of a conventional air-insulated capacitor. An electron may be near the negative plate or ejected from the metal plate by an incident photon of radiant energy from outside the capacitor. Force of repulsion from the negative plate almost instantly gives the electron a velocity toward the positive plate approaching order of 20 million centimeters per second. Through collisions of the fast-moving electron with neutral atoms and molecules of intervening air, outermost planetary electrons may be knocked out of the atoms. This electron dislodgement occurs when impact energy becomes sufficiently great. Of course, loss of an electron from a neutral atom or molecule causes formation of a pair of negative and positive ions. This process of creating negative and positive ions is called "ionization by collision."

A high-velocity free electron, as in the electric field of the charged capacitor assumed above, creates a tremendous multiplication of electrons and positive ions as the progeny of dislodged electrons advance toward and finally reach the positive plate. This characteristic growth of electron population is known as an "electron avalanche."

To illustrate the enormous growth of electron population during a single electron-initiated avalanche, assume the potential gradient at the negative plate of the capacitor to be about 31 kv/cm. Threshold energy required for the initiating electron to create the first pair of ions by collision occurs about 0.04 centimeter away from the negative electrode. Halfway across the one-centimeter gap, about 5000 electron and positive-ion pairs have formed. Three-quarters of the way across the gap, nearly ½ million electron and positive-ion pairs have formed. At a distance of about 0.04 centimeter from the positive plate, electron and positive-ion population has increased to nearly 12 million.

Time of travel

Electrons, for the most part, reach their destination at the positive plate during the electron avalanche, as described, in approximately one-tenth microsecond. On the other hand, the low mobility of the heavy positive ions (which is the order of 0.01 to 0.0001 that of electrons) causes the positive ions during this short period to remain practically immobilized as ions at their locations of birth. Mechanism of spark occurrence shows spark-

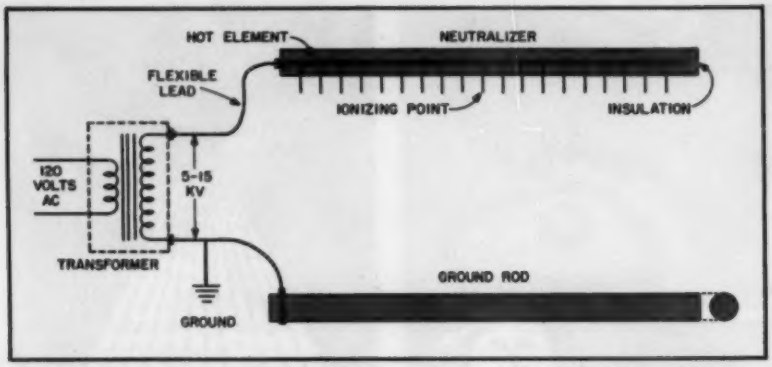


Fig. 4 — "Hot" electrode of an ac static neutralizer is conductively connected to ionizing points and energized from high potential transformer terminal.

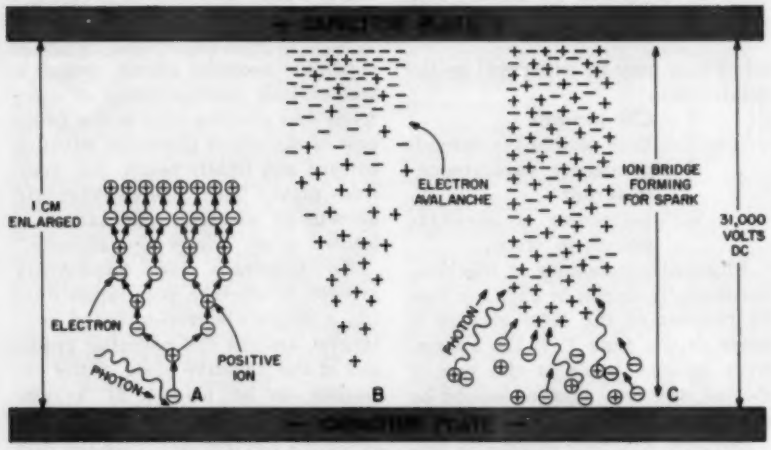


Fig. 5—Electrons repelled from negative capacitor plate toward positive plate collide with neutral atoms and multiply electric progeny into an avalanche.

over voltage is considerably less for needlepoint gap.

Replacement of the two parallel capacitor plates with a capacitor comprising an array of needle points and a ground rod (as are commonly used in high-voltage static neutralizers) greatly affects electric field distribution. Electric field in this situation is changed from one of uniform density, as in the plate capacitor, to one of high distortion, especially near the points. Such a system of electrodes is shown in Fig. 4. Concentration of electric field at a needle point when it is negatively electrified to dc potential increases potential gradient there for a given applied voltage. This condition multiplies ionization activity at the negative point by 2.5 to 3 times and accounts for the much lower sparkover voltages required to initiate spark occurrence for needlepoint gaps.

If the point-to-plane capacitor system is electrified with the point at positive polarity, as shown in Fig. 5, formation of negative and positive ions in the gap is much less than when the needle point is negatively electrified. Geometry of electrodes, in general, plays an important part in the process and magnitude of ionization by collision. Ground rod in neutralizers, by being smooth and of extensive area compared with the ionizing points, lacks high potential gradient which characterizes point electrodes. For this reason, the degree of ionization within the gap is decimated.

Corona glow explained

When the point-to-ground system of electrodes for static neutralizers is energized with alternating current, as all high-voltage neutralizers are, copious ionization occurs for part of the half-cycle when the ionizing points are highly electrified to negative polarity. Ionization, on the other hand, is relatively small during the succeeding half cycle when ionizing points are electrified to positive polarity.

During ionization of air, vast numbers of positive and negative ions formed undergo recombination. As this occurs, a photon of radiant energy is liberated from each such recombination. These photon units of energy become visible when at least five of them enter the eye and reach retinal receptors during exposures of one millisecond. Purplish corona glow may be readily seen in a dark room where electric wires are operated at voltages that give potential gradients at their surfaces in the order of 31 kv/cm or higher. Corona in air creates ozone which is detectable by its pungent odor. Ozone is a most active form of oxygen. It attacks and rapidly deteriorates many types of insulation used in the electrical industry. When potential gradients are sufficiently high to create excessive ionization, power loss occurs along the transmission line. This is commonly referred to as the "corona loss."

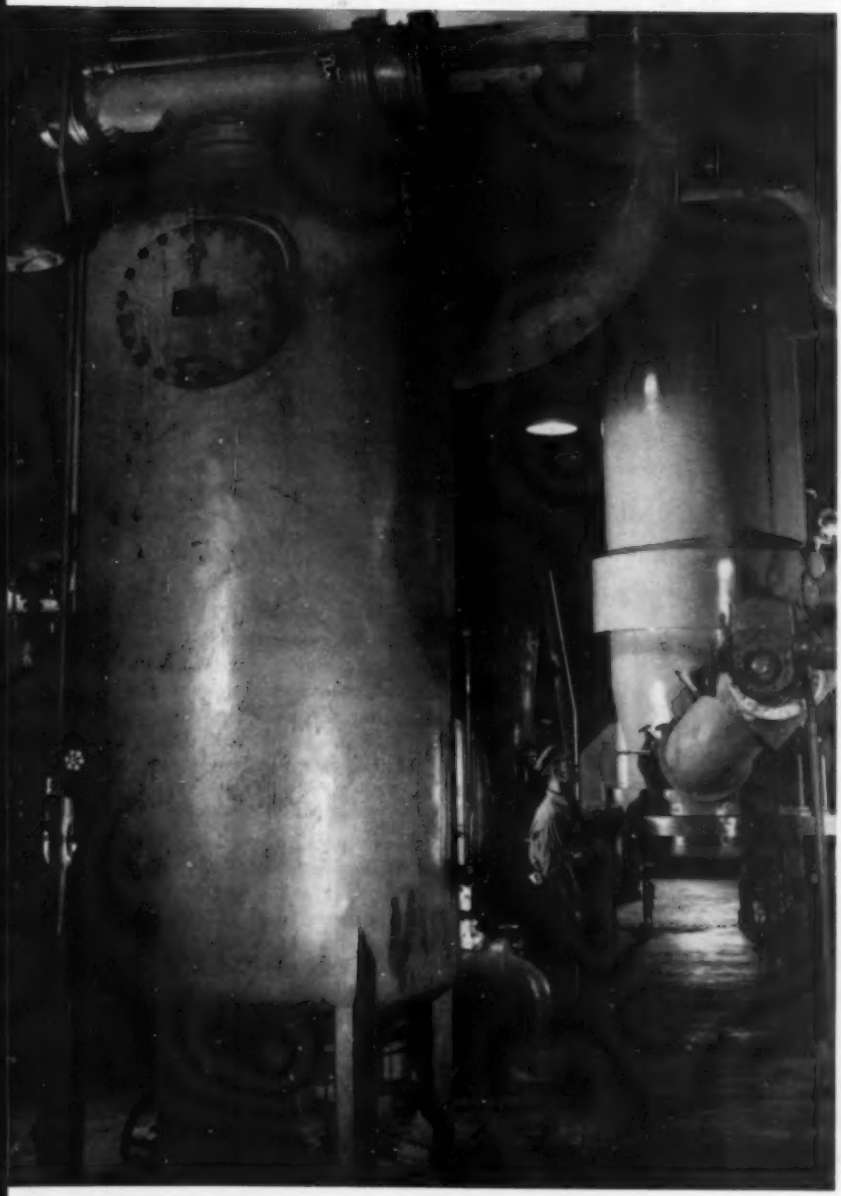
Fluid flow can generate charges

In addition to contact between solid dielectric substances by other substances to generate static electricity, static electricity also occurs from dielectric liquid flowing in pipelines — such as gasoline, kerosene, and fuel oil. Innumerable other dielectric liquids generate static electricity while flowing in, and thus making contact with, inside surfaces of metal pipes, hose lines, glass pipes, and the like. Gases, steam, and other vapors flowing turbulently through metal pipes or hose lines generate static electricity. Storage of compressed gases in cylinders for shipment and for use in industry is dangerous because of static electricity. Explosions resulting in great property damage and loss of life have occurred when cylinders were being filled or when compressed gas from cylinders was improperly discharged. Effects of static electricity are indeed costly to industry. To be combatted, they first must be understood fully.

How to select

boiler *CORROSION CONTROL* equipment

RALPH M. LEMEN
Permutit Company



COMPLETE ELIMINATION of dissolved oxygen and free carbon dioxide is necessary to minimize corrosion in feedwater lines, boiler internal surfaces, and condensate return lines. Reduction of carbon dioxide present as bicarbonate or carbonate alkalinity, however, depends upon plant requirements as related to boiler pressure, quantity of condensate returns, and steam usage.

Solubility of noncondensable gases (oxygen and free carbon dioxide) is zero at boiling temperature. Removal of these gases, therefore, can be accomplished by boiling the water either in contact with steam or under vacuum (as in cold water deaeration).

Reboiling spray-type deaerating heaters (Fig. 2) deaerate water in three stages. First stage is primarily a vent condenser, either direct-contact or external-tubular type. It concentrates noncondensable gases before discharging them to atmosphere. In the second stage, water is heated almost to steam temperature, and then sprayed into a steam atmosphere. This removes most noncondensable gases. Hot, partially deaerated water passes to the third or reboiling stage for final and complete deaeration.

Steam to heat the water is first delivered to the reboiler or steam scrubber section. Partially deaerated and preheated water from the second stage is uniformly distributed to reboiler bottom section by a water distributing weir. Water passes upward through this section directly in front of the steam distributor plate.

Vigorous scrubbing

Final and complete deaeration is accomplished in this third stage of the reboiler section by vigorous scrubbing action of water and steam. Completely deaerated water and steam separate at the top of the reboiler section. Water then spills over into storage space and steam passes to the second stage for heating incoming water.

Tests performed on a reboiling-type deaerator demonstrate the high degree of deaeration ac-

Fig. 1—Boiler feedwater system for a high-pressure, high volume operation.

complished with this design. Primary purposes of this particular test were to determine effectiveness of oxygen removal at various loads, and effect of using oxygen-contaminated vapor from an evaporator for deaeration.

Data given in Table I demonstrates high deaerator efficiency for oxygen removal when steam delivered to scrubber section is not contaminated with oxygen. Results were not as good when incoming steam was contaminated with oxygen.

Reboiler-type deaerating heaters, in addition to eliminating dissolved oxygen in feedwater, remove all free carbon dioxide. This is evident by the considerable increase in water pH value. Free carbon dioxide is practically the only gas that causes a low pH in water. If free carbon dioxide is present in water, pH will be less than 8.3. However, a pH of 8.3 or above indicates that all free carbon dioxide, as determined by American Public Health Association's Titration Method, is removed.

Results of reboiler-type deaerator test showed that effluent water had a pH from 8.4 for an operating pressure of 1 psig, to as high as 10.1 for an operating pressure of 120 psig (Table II). Values of pH above 8.3 result from carbon dioxide being removed by deaeration beyond that present as free carbon dioxide due to dissociation of bicarbonate radicals. At an operating steam pressure of 120 psig, all free carbon dioxide in the influent water was removed, as well as carbon dioxide in bicarbonate alkalinity form. More than half the carbon dioxide of normal carbonate alkalinity was changed to hydroxide. This indicates that nearly half the carbon dioxide in normal carbonate form was removed by deaeration. It is evident, therefore, that such an efficient mechanical deaerating heater will remove all oxygen and free carbon dioxide. It will also give a pH value above 8.3 to provide maximum protection against corrosion in the boiler.

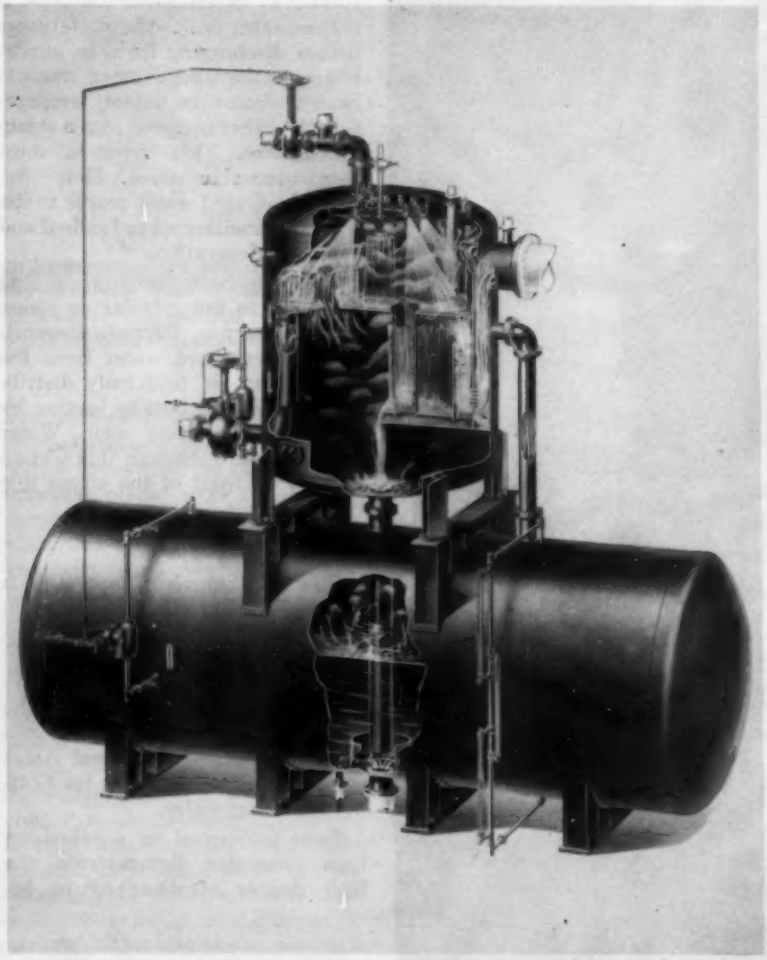


Fig. 2—Reboiling spray-type deaerating heaters treat water in three stages. Cascading influent water spreads into thin films to allow escape of gases.

Vacuum deaeration

Fundamental principles that apply to deaeration at high temperature also apply to vacuum or cold water deaeration. The difference is that vacuum is employed to lower the water boiling temperature.

In a vacuum deaerator, influent water cascades over staggered trays or Raschig Rings to spread the water into thin films. This allows noncondensable gases to escape from the water under boiling conditions. These gases are removed from the deaerator by either vacuum pumps or multistage steam jet ejectors. Pumps or jets also maintain proper vacuum in the tank to permit the boiling of the water to take place at low temperatures.

Corrosion caused by oxygen and carbon dioxide is not nearly as active at low temperatures. Complete removal of gases, therefore, is not as essential as at high temperatures. Oxygen residuals in effluent water from a vacuum deaerator of approximately 0.3 to 0.5 ml/l are usually satisfactory.

Vacuum deaerators are often used to prevent corrosion in cooling water systems, condensers, air conditioning systems, surface water supplies, and demineralized or chemically treated process water.

Removing bicarbonate alkalinity

Carbon dioxide in boiler feedwater as bicarbonate or carbonate alkalinity can be removed by several methods. Method used depends upon degree of alkalinity reduction desired. Other factors to be considered are water analysis, quantity of condensate returns, boiler pressure, and end use of steam. Often, however, reduction of alkalinity to very low limits is not as necessary at low boiler pressures as at high boiler pressures.

Degree of alkalinity reduction

TABLE I — OXYGEN IN DEAERATOR EFFLUENT

Turbine load megawatts	Evaporator off ml/liter	Evaporator on ml/liter	Steam from Evaporator percent
15	0.0005	———	——
20	0.0000	0.0064	20.2
40	0.0009	0.0027	56.0
60	0.0010	0.0012	46.4
80	0.0027	0.0039	34.5

TABLE II — pH VALUES OF DEAERATED EFFLUENT

Case	Capacity of Deaerator lb/hr	Steam Pressure for Deaeration psig	M. O. Alkalinity of Effluent ppm vs $CaCO_3$	Influent pH	Effluent pH
1	60,000	1	10	5.6 to 6.0	8.4
2	200,000	5	18	6.6 to 7.4	8.7
3	1,400,000	14	16	6.8	8.9
4	200,000	28	18	7.4 to 7.8	9.4
5	750,000	120	11	6.4	10.1

desired depends on type of treatment used (Fig. 3).

Sodium Zeolite softening

Straight sodium Zeolite softening passes water through a bed of natural Zeolite, carbonaceous Zeolite, or synthetic Zeolite resin. This process exchanges calcium and magnesium salts for sodium salts without affecting total alkalinity.

Cold or hot lime-soda softening reduces hardness and alkalinity through chemical precipitation with lime and soda ash.

In hot process treatment, development of a new sulfonated styrene resin that is stable at high temperatures makes it possible to soften the effluent water from the hot process unit to zero. This is done by passing hot treated water through a styrene resin bed. With the latter treatment, soda ash is eliminated and lime is used to reduce carbonate alkalinity to low levels. Excess hardness is then removed in hot Zeolite softeners. This treatment produces a boiler feedwater of zero hardness and low alkalinity. It is generally considered good feedwater for boiler pressures up to approximately 600 psig.

Sodium-Hydrogen Zeolite systems

Sodium and hydrogen Zeolite systems give complete hardness removal plus reduction in alkalinity. Sodium Zeolite unit and hydrogen Zeolite unit are operated in parallel. Incoming raw water is split between units in proportion to raw water alkalinity, free acid contained in hydrogen Zeolite effluent, and alkalinity desired in final mixed effluent. Alkalinity in effluent water from this equipment usually ranges from 10 to 15 ppm. Thus, very little carbon dioxide is carried to the boiler steam. This treatment is generally satisfactory for boiler pressures from 600 to 800 psig.

Introduction of highly basic anion exchange resin has focused attention on boiler feedwater dealkalization. This treatment removes hardness and reduces alkalinity without use of an acid regenerant. Water is first softened by a sodium Zeolite softener. Effluent is then passed through a highly basic anion exchange unit. Both units are regenerated with salt. Alkalinity for average raw water can be reduced to approximately 5 to 15 ppm. Sulfates in the water can be reduced to about 3 to 5 ppm. Since sodium chloride is used as the regenerant, chlorides in the effluent water are increased by the amount of alkalinity and sulfate reduction. One refinement of this treatment is to mix caustic soda with salt regenerant brine to give an effluent alkalinity in carbonate rather than bicarbonate form. This further reduces amount of carbon dioxide released to the boiler steam.

Sodium Zeolite plus acid

Complete as well as partial alkalinity reduction can be accomplished by sodium Zeolite softening followed by acid treatment. Water is first passed through a sodium Zeolite softener, where all hardness is removed. Acid is then fed into the effluent water by controlled feeding equipment to destroy bicarbonate alkalinity. To eliminate carbon dioxide in the boiler steam, enough acid must be fed to allow for slight free mineral acidity in the water. This results in low pH and produces an effluent water that is

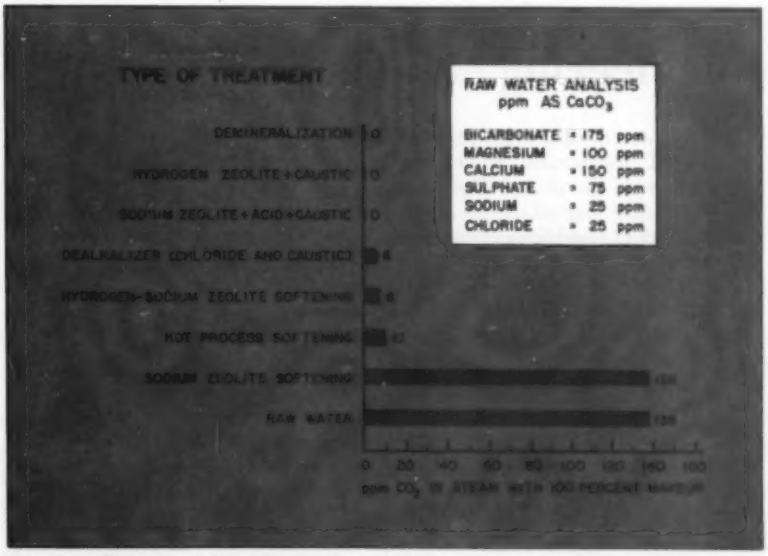


Fig. 3—Alkalinity reduction can be obtained using various raw water treatments. Results of some treatments are comparable to the use of evaporators.

quite corrosive. Free carbon dioxide must be completely removed by a degasifier and a deaerating heater. Caustic soda is then generally added to the water to raise the pH value.

Hydrogen Zeolite plus caustic

With this treatment, hydrogen Zeolite unit is used to remove all hardness from the water. Unit also changes bicarbonates, carbonates, sulfates, and chlorides to their corresponding acids. Effluent water will contain carbon dioxide as a result of breakdown of alkalinity. It will also have free mineral acidity. All free carbon dioxide must be removed in a degasifier and deaerator. Caustic is then usually fed to neutralize free mineral acidity. Caustic must be added following complete carbon dioxide removal. Otherwise, carbon dioxide would be fixed by caustic as carbonates—putting alkalinity back into the water.

Demineralization

Some public utility power plants and some industrial plants are installing the comparatively new demineralization process to obtain chemically pure water for boiler feed purposes. Demineralization will produce a water completely free of alkalinity. This eliminates possibility of free carbon dioxide passing off with steam and eliminates low condensate pH.

Earlier demineralizing systems used the weakly basic anion exchange resin. Main disadvantage of this system is its inability to remove silica from water.

Some plants have used fluorides to obtain silica removal with demineralization. This treatment was expensive and presented many problems in feeding fluorides. Therefore, the evaporation process was favored when silica was present in raw makeup water. However, recent development of the highly basic anion exchange resins makes it possible to remove silica as well as other mineral matter by the demineralization process. Thus, boiler feedwater equivalent to that obtained using evaporators is produced at lower operating cost.

Equipment generally consists of a cation exchanger followed by a highly basic anion exchanger. Cations or positive ions in water are removed in passing through the hydrogen cation exchanger. Anions or negative ions are removed in passing through the anion exchanger. This new anion exchange resin will remove all negative ions including silica. It will also remove free carbon dioxide released in passing through the first unit.

It is often more economical to place a degasifier between the first and second units if carbon dioxide in effluent from the first unit is high. This reduces carbon dioxide to approximately 10 ppm. The remainder is removed in the anion exchanger.

Boiler corrosion control increases

As industrial plants and public utilities continue to expand, need for higher boiler pressures increases. Also, higher plant operating costs plus water shortages have emphasized the need for more complete recovery of steam condensate. With this trend, problems connected with corrosion control become more complex. Complete study of such problems plus proper water treatment is required to reduce costly material replacements and plant shutdowns resulting from deterioration of metals in contact with water.

Many companies have recognized the seriousness and destructive force of corrosion and have adopted full-scale corrosion control programs. Basic to such programs is selection of equipment best suited to the individual needs of each plant.

Engineering abolishes slavery

In our world, the engineer has substituted mechanical power for the muscles of the slaves. Our profession, in the last analysis, is devoted to the development of the sources of mechanical power from some heat or other engine, including the nuclear reactor, and the machine in which the power is applied for our benefit. As a result, the cost of power has been reduced to a point below that of the cheapest slave. In our engineer world, and only in our engineer world, slavery is uneconomical and, therefore, has ceased to exist. It still exists in the countries today comprising the pre-engineer world. That is the reason our ships transport power-using machines and power-producing plants of all kinds instead of the human slaves they carried during the countless centuries of the pre-engineer world.

Please do not misunderstand; the engineer did not set out to abolish slavery, but by his power producing equipment and his machines powered by mechanical energy he did remove the need for slavery. This is his greatest achievement in Commerce and Industry—the engineer removes the need for slavery.

By removing the need for slavery, previously recognized as the essential basis of civilization, he has given the humanitarians the opportunity to abolish its legal status. . . .

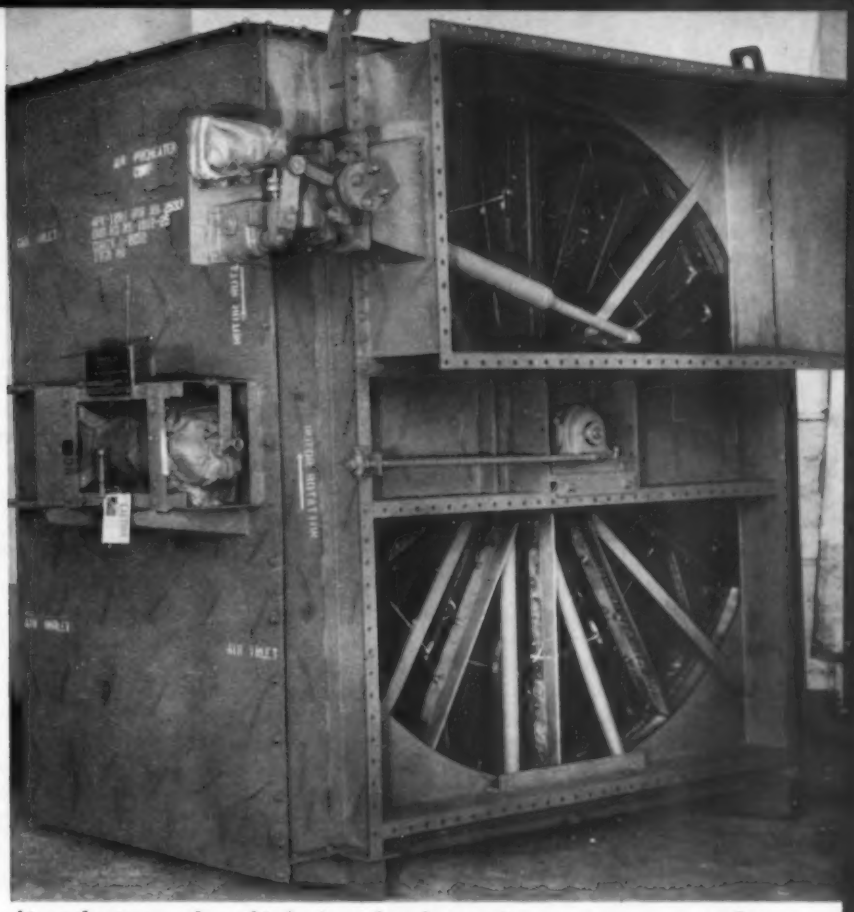
The world has found that the breeding and use of mechanical-power-driven metal slaves has become the basis of all engineer-world commerce and industry, just as human slaves were and are the basis of all pre-engineer civilizations.

Although many figures have been given, yet they may all be summarized by saying that in the pre-engineer civilizations the average number of human slaves per free man varied from one to ten—every American today has the equivalent on an energy basis of 260.

Crosby Field
President
Flakice Corporation

WILLIAM E. HAMMOND

STEPHEN J. ZIERAK
The Air Preheater Corporation



Air preheaters, such as this horizontal package unit, may save you up to five percent of your fuel bill—worth considering even if your plant is only small.

Computing fuel *SAVINGS* with economizers, air preheaters

EVER-RISING fuel costs warrant investigation and evaluation of heat recovery equipment by operators of even smaller-sized industrial steam and process plants. To evaluate this equipment, several factors must be considered:

¶ Fuel costs
¶ Amount of fuel that can be saved
¶ Cost of heat recovery equipment
¶ Costs of installing this equipment on both new and existing installations.

In evaluating heat recovery equipment, one of the first things to consider is future fuel cost. Let us assume that equipment life is 20 years. Then fuel cost for equipment purchased in 1955 should be based on fuel cost in 1965, which could very well be the average of the 20-year span. Fuel costs over past years could be tabulated and future costs easily estimated.

Graphs presented at the American Power Conference in March 1955 show a sharp increase in fuel prices during the past 10 years. Average cost of bituminous coal and lignite (as shown by the trend line) was $8.05/ton in 1953. Bunker C oil at New York cost an average $2.15/barrel. For natural gas, average cost was 20.6 cents/1000 cu ft. By projecting this trend line to 1955 and on through to 1975, the average 1965 fuel cost for coal, oil, and natural gas will be $11.05/ton, $2.75/barrel, and 24.2 cents/1000 cu ft, respectively.

Heat recovery

Naturally, amount of fuel saved by air preheater or economizer (which is directly proportional to amount of heat saved) is just as important as fuel cost.

An air preheater or economizer

utilizes waste heat in flue gases from the boiler to preheat combustion air or boiler feedwater, as the case may be. Raising combustion air temperature lowers Btu input required from the fuel to make a given quantity of steam. Therefore, less fuel is required. With an economizer, Btu required to heat feedwater to steaming temperature decreases as incoming boiler feedwater temperature increases. For every 40 F rise in air inlet temperature and every 10 F rise in feedwater temperature entering a boiler, gain in efficiency will be approximately one percent.

Heat savings with an air heater or economizer can be calculated from examination of flue gases leaving the boiler. Heat in these gases is composed of sensible heat in the combustion gases themselves, plus heat in water vapor formed from burning of hydrogen in the fuel. Flue gas will also contain water vapor from carryover of moisture in both the fuel and air used for combustion. However, this is negligible.

Curves may be plotted that will show percent of combustion loss against flue gas temperatures that result from burning coal, oil, and natural gas. Sample calculation for percent combustion loss with natural gas firing when combustion gases leave a boiler at 600 F is shown in Steps 1 through 9 (Fig. 1). These curves are useful in determing percent efficiency gained by reducing flue gas temperature leaving a boiler.

Assume that effluent flue gases are at 600 F. We want to reduce their temperature to 300 F. If the boiler is burning natural gas, we find from Fig. 1 (Steps 1 through 9) that efficiency gain resulting from installation of an air heater or economizer would be 7.2 percent (22.2 –15.0 percent).

Estimate efficiency gain

Taking difference in percent combustion loss between two exit gas temperatures for a given fuel gives a quick and conservative estimate of gain in efficiency. This allows for unforseen boiler outages and reduced operating loads. For new boilers or existing installations where operating load and outage time can be accurately determined, this formula should be substituted for Step 10 (Fig. 6):

Fuel savings =

$$W\left[1-\frac{\left(\begin{array}{c}100\%\text{ combustion loss at}\\ \text{original gas temperature}\end{array}\right)}{\left(\begin{array}{c}100\%\text{ combustion loss at}\\ \text{desired gas temperature}\end{array}\right)}\right]$$

where W = pounds or cu ft of fuel originally burned

Curves (Figs. 2, 3, and 4) summarize benefits of heat recovery equipment. Because each fuel has many different ultimate analyses and is used with different amounts of excess air, percent combustion loss for different flue gas temperatures naturally will vary. If an exact figure is desired, use method outlined in Figs. 1 and 6.

Ultimate Analysis (percent by volume)		Mols/mol fuel				Ultimate Analysis (percent by weight)
CH_4	93.00	.9300 X 16	lbs/mol = 14.88	lbs ÷	16.40 X 100 =	90.71
C_2H_4	.20	.0020 X 28	.06		16.40 X 100 =	.37
CO	.50	.0050 X 28	.14		16.40 X 100 =	.86
CO_2	.20	.0020 X 44	.09		16.40 X 100 =	.55
H_2	1.90	.0190 X 2	.04		16.40 X 100 =	.25
O_2	.40	.0040 X 32	.13		16.40 X 100 =	.79
N_2	3.80	.0380 X 28	1.06		16.40 X 100 =	6.47
		1.0000 mol fuel	16.40 lbs/mol fuel			

Note: For coal and oil fuels, this tabulation is not necessary since their ultimate analysis is in percent by weight. Therefore, calculations can begin with step one.

1. Weight of air required (per pound fuel) at 0 percent excess air = 17.28 (.9071) + 14.8 (.0037) + 2.47 (.0086) + 34.55 (.0025) − $\frac{.0079}{.2315}$ = 15.81 pounds.
   Note: In any ultimate analysis, CO_2 and N_2 does not require air for combustion. O_2 supports combustion, therefore, decreasing the amount of air (containing 23.15 percent O_2 by weight) necessary to burn combustibles in fuel.
2. Weight of air required (per pound fuel) at 12 percent excess air = 1.12 (15.81) = 17.7 pounds.
3. Weight of flue gas (per pound fuel) at 12 percent excess air = 17.7 pounds air + 1 pound fuel = 18.7 pounds.
   Note: For coal, weight of ash appearing in ultimate analysis must be deducted.
4. Weight of H_2 (per pound fuel) = .9071 (.25) + .0037 (.143) + .0025 = .23 pounds.
5. Weight of water vapor in flue gas (per pound fuel) = 9 X .23 = 2.07 pounds.
   Note: Pounds of H_2 is always multiplied by 9 to obtain weight of water vapor.
6. Weight of dry flue gas (per pound fuel) at 12 percent excess air = 18.7 — 2.07 = 16.63 pounds.
7. Heat loss in Btu due to water vapor in flue gases (per pound fuel) = W [(212-t) + 970.4 + .48 (T-212)]. Where W = weight of water vapor; t = air temperature into boiler; T = temperature of flue gas; 970.4 is latent heat to evaporate one pound water at 212 F to steam and .48 is mean specific heat of superheated steam. With 80 F air and 600 F flue gas, heat loss = 2670 Btu/lb fuel.
8. Heat loss in Btu due to sensible heat in dry flue gas per pound fuel = W_1 (.25) (T-t), where W_1 = weight of dry flue gas and .25 is mean specific heat of flue gases; heat loss = 2160 Btu/lb fuel.
9. Percent combustion loss at 600 F flue gas = $\frac{2670\text{ Btu} + 2160\text{ Btu}}{21{,}800\text{ Btu}}$ X 100 = 22.2 percent, where 21,800 is heating value in Btu/lb fuel; similarly, with 300 F flue gas, combustion loss = 15.0 percent.
10. Assuming 50,000 cubic feet of natural gas burned per hour and gas temperature drop of 300 F, fuel savings = 50,000 (22.2 percent — 15.0 percent) = 3600 cu ft/hr.

Fig. 1—Sample calculation of combustion loss for natural gas firing. For coal and oil, start at step 1. Plot information against flue gas temperatures.

Information to calculate weight of air required to burn a given fuel is tabulated in Fig. 6. It also gives information necessary for calculating weight of hydrogen in the ultimate analysis of a given fuel when it is not separated from other consultants.

Method of calculating percent of combustion loss at any given flue gas temperature for any fuel is given in Fig. 1. Sample calculation shown in Fig. 1 is based on natural gas fuel since this is more informative. Ultimate analysis of natural gas is given in percent by volume, so it is necessary to convert it to percent by weight. Since ultimate analyses of solid and liquid fuels are given on a percent by weight basis, there is no need for this tabulation for fuels such as coal and oil. For these fuels, the calculation can begin with step 1.

There are limitations

In evaluating an air heater or economizer, some limitations affect their selection. With stoker-fired boiler installations, maximum air temperature leaving the air heater is limited to about 300 F. Stokers cause clinkering and require excessive maintenance if air temperatures higher than 300 F are used for combustion. Based on 80 F air to the air heater, maximum air temperature rise will be about 220 F. Reduction of gas temperature (gas drop) through an air heater is proportional to air temperature rise and may be calculated from this formula:

$$\text{Gas Drop} = \frac{W_a \times C_{pa} \quad \text{(Air Rise)}}{W_g \times C_{pg}}$$

where W = wt of gas or air flow through air heater

C_p = average specific heat.

For regenerative air heaters, this formula must be corrected for air leakage into the gas side of heater. Using a gas drop of 0.8 F for every degree rise in air temperature, gas drop for a 220 F rise in air temperature will be 176 F. Therefore, reduction in flue gas temperature will not be as great as could be obtained with other types of firing, because of limits on air temperature entering a stoker-fired boiler. For pulverized coal, oil, and natural gas, air temperature entering the boiler is not limited, and may be as high as 600 F where economical. Naturally, to obtain an air temperature of 600 F, a flue gas temperature of about 700 F or higher is required.

Maximum flue gas temperature entering an air heater is limited to about 900 F. If special steels are used in the air heater this temperature can be exceeded, but cost is increased considerably. Minimum flue gas temperature leaving the air heater should not be lower than dew point of water vapor in the gas.

For nonsteaming economizers, general practice limits maximum temperature of feedwater leaving the economizer to about 50 F below saturation temperature. Saturation temperature, of course, is dependent upon boiler working pressure. In most cases, this point will not be reached because of the economics of the economizer heating surface or because flue gas temperature is not high enough. For steel tube economizers, feedwater should be properly deaerated and heated to a minimum of about 220 F before entering economizer. Flue gas temperature limitations for an economizer are about the same as those described for an air heater. To calculate gas drop through an economizer for a given rise in feedwater temperature, use this formula:

$$\text{Gas Drop} = \frac{W_w - C_{pw} \quad \text{(Water Rise)}}{W_g \times C_{pg}}$$

where W = wt of water or gas flow through economizer

C_p = average specific heat of each.

Fuel and dollar savings

Heat savings from installation of heat recovery equipment result in fuel savings. Fuel savings, dollar savings, and time to amortize a regenerative package air heater are plotted against flue gas temperature drop on Figs. 2, 3, and 4, for coal, oil, and natural gas.

As an example, assume boiler uses 3000 lb/hr of Bunker C oil and operates 5000 hours a year, as shown in Fig. 3. Temperature of flue gas leaving boiler is 600 F. It is desirable to reduce the temperature to 350 F. For a gas temperature drop of 250 F (600 F—350 F), curves show fuel savings of 179 lb/hr, $7400 saved per year, and an amortization of 1.4 years. If boiler had burned 2000 lb/hr of oil and had operated 4000 hours per year, savings would have been

$$179 \frac{(2000)}{(3000)} = 119 \text{ lb/hr and}$$

$$\$7400 \frac{(2000)\ (4000)}{(3000)\ (5000)} = \$3945 \text{ per yr.}$$

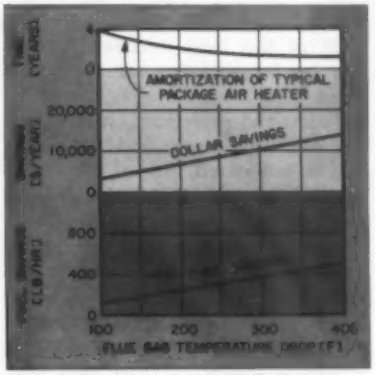


Fig. 2—Based on coal consumption of 5000 lb/hr, 5000 hr/yr, and $11.05/ton.

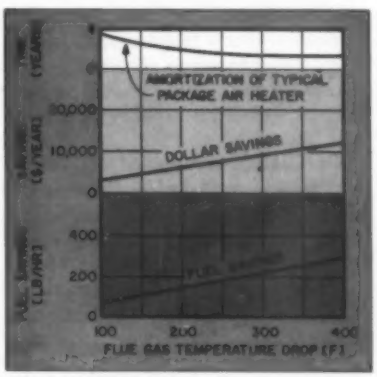


Fig. 3—Based on oil consumption of 3000 lb/hr, 5000 hr/yr, and $2.75/bbl.

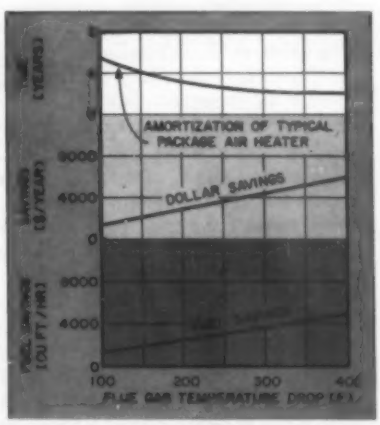


Fig. 4—Based on 50,000 cu ft/hr gas usage, 5000 hr/yr, and 24.2¢/1000 cu ft.

It would require 1.4 $\frac{(3000)\ (5000)}{(2000)\ (4000)}$ = 2.62 years to amortize the air heater.

It is difficult to make a general statement as to time required to amortize installation of heat recovery equipment since this is dependent upon so many factors. Cost of the heat exchanger itself can be found by obtaining a bid from the manufacturer. Cost of erection and materials (such as additional flue work and supports) can be estimated. Added resistance (on both gas side and air side) of the boiler system resulting from installation of heat recovery equipment increases fan capacity required.

On flue gas side, this equipment will give a resistance of 2 to 4 inches of water. It will also give about the same resistance on air side of system. With an economizer, boiler feedwater pump must be able to produce an additional pressure of 10 to 20 psi because of economizer's resistance to water flow. Maintenance costs over a period of years are difficult to predict, but with reasonable care they will be small.

Installation allowance of 50 percent that is included in the amortization curves is very conservative when an evaluation is being made for a new installation. Cost of additional fan capacity required, supporting structure, erection costs, and added power consumption are more than covered. With existing boiler installations, allowance should cover package air heater installation costs, in most cases.

Existing boiler installations

Evaluation of heat recovery equipment for existing boiler installations also involves cost of revamping forced and induced draft fans to accommodate added resistances from this equipment.

Forced draft fan will handle about 5 to 10 percent less air with an air heater than without. Since air is blown into heater, fan will still operate at the same temperature as before. Therefore, it will handle less volume. Because of this, fan will usually give more static pressure, which will help to compensate for added resistance. On the other hand, system resistance (which determines the fan's operating characteristics) will increase due to higher temperature air leaving the air heater. Even though there will be less weight of air in the system, volume of air will be greater than before air heater was used. Therefore, the forced draft fan has to handle a static pressure even greater than the additional resistance of the air heater.

Addition of an air heater or economizer to a boiler system will affect the induced draft fan somewhat differently from the forced draft fan. An ID fan sucks gases from the air heater or economizer so that lower temperature gas leaving either of them will increase its static pressure output. Static pressure at any volume will increase as the ratio of higher absolute temperature divided by lower absolute temperature. Volume of gas that fan must handle will be somewhat less than before. This is due to fan handling less weight of gas at a lower temperature. Unlike the forced draft fan, system resistance will slightly decrease, thus helping the induced draft fan to take the added resistance of the air heater or economizer.

As an example of how the addition of an air heater will affect fans of a boiler now operating without an air heater, let us assume these conditions: A boiler is oil fired and requires 46,500 lb/hr of 80 F air; resistance of burner and duct work is 2.5 in. wg; quantity of flue gas leaving boiler is 54,500 lb/hr at 600 F; resistance of boiler and ducts is 3.0 in. wg.

Both forced draft and induced draft fans should be designed for quantities larger than those given as a safety factor for unforeseen conditions. Fans should be designed for a 10-percent greater quantity of air or gas and a 20-percent greater static pressure than required. Let us assume that fans are direct-motor driven and will be controlled with outlet dampers. Forced draft fan performance will be as shown in Fig. 5.

Since fan is directly driven by a motor, a 10-hp, 1200-rpm motor is required. It will be seen that fan required only 1105 rpm to give fan design performance. When direct drive is used, however, fan speed is limited to motor speeds. Manufacturer must use a slightly oversize fan if his series of stand-

	FORCED DRAFT FAN			INDUCED DRAFT FAN		
	Before installing air heater		After installing air heater	Before installing air heater		After installing air heater
	Boiler at full load	Fan Design	Boiler at full load	Boiler at full load	Fan design	Boiler at full load
Air or Gas [lb/hr]	46,500	51,000	48,100	54,500	60,000	55,600
Temperature [F]	80	105	80	600	650	300
Volume [cfm]	10,500	12,100	10,900	23,200	26,800	17,000
Static Pressure [in. wg]	2.5	3.0	6.0	3.0	3.6	6.0
Fan speed, [rpm] (if operated at variable speed)	974	1105	1328	727	825	773
Fan efficiency [percent]	70.9	69.8	81.5	62.2	60.5	77.2
Horsepower at fan speed	5.8	8.2	12.6	17.7	25.1	20.7
Full load motor speed	1150	1150	1770	875	875	875
Fan efficiency at motor speed	46.8	62.6	41.0	42.7	53.6	58.4
Horsepower at motor speed	8.8	9.1	25.2	25.8	28.4	27.4

Fig. 5—Performance of both forced and induced draft fans in example are compared with their design performance.

ard fans does not hit exact motor speed for specified conditions. This gives a little more safety factor than was asked for, and requires a little more horsepower. Note that for full-load boiler conditions, horsepower requirement is almost as great as fan design condition even though volume and static pressure are smaller. This follows because of mechanical resistance added to system by the fan outlet damper.

Air heater used in this example gives a fuel savings of 7.2 percent so that weight of air required for combustion is 43,100 lb/hr instead of 46,500 lb/hr. Allowing for leakage through heater, total air to be handled by fan is 48,100 lb/hr. Allowing for increased resistance through system and air heater, static pressure requirement of the fan is 6.0 in. wg. Fan must be operated at 1328 rpm to meet the new condition. This new speed can be obtained by using a V-belt drive or using the next higher motor speed and dampering the fan. In this case, it would require excessive dampering, which would not be economical since 25.2 hp would be required (compared to 12.6 hp if fan were V-belted). Good engineering prefers that fan run at 1500 rpm with a V-belt drive so that there would be about the same safety factor in the fan. This would require about 18.2 hp, and a 20-hp motor would be required instead of a 15-hp motor. If fan were run at 1500 rpm, small fan involved probably would not demand a new fan shaft. However, if fan were run at 1770 rpm with direct-motor drive, new shaft and bearings and possibly a new wheel might be required.

TABLE I

Wt. of one mol of each component found in fuel ultimate analysis (lbs)
C — 12
O_2 — 32
H_2 — 2
S — 32
N_2 — 28
CO — 28
CO_2 — 44
H_2S — 34
CH_4 — 16
C_2H_4 — 28
C_2H_6 — 30
C_3H_8 — 44
C_4H_{10} — 58
C_5H_{12} — 72

TABLE II

Air required to burn one pound of each component in fuel (lbs)
11.52
—
34.55
4.32
—
2.47
—
6.09
17.28
14.80
16.15
15.70
15.45
15.38

TABLE III

Hydrogen in one pound of each component in fuel (lbs)
—
—
—
—
—
—
—
.059
.250
.143
.200
.182
.172
.167

TABLE I — Used to convert the ultimate analysis of gaseous fuels from the volumetric basis (in which it is generally given) to weight basis. It is not necessary to use this table for solid and liquid fuels since ultimate analysis is given on a weight basis.

TABLE II — Used to calculate the pounds of air required to burn one pound of fuel with no excess air. Ultimate analysis of fuel (in percent by weight) is assumed to total one pound of fuel. Thus, each percent of component divided by 100 is the weight of that component in one pound of fuel.

TABLE III — Used to calculate the pounds of hydrogen in one pound of fuel. It is necessary to use this table for gas and oil fuels since the ultimate analysis shows H_2 combined with S and C. It is not necessary to use this table for coal. Sometimes, the ultimate analysis of oil separates out all of the H_2 in the fuel, in which case this table is not needed.

Fig. 6—Information needed to calculate amount of air required to burn various fuels, and water vapor in gases that result from burning hydrogen.

Use same ID fan

After examining this performance, note that the same ID fan (without alterations) may be used when an air heater is added to the system. Same safety margin that was called for when fan was purchased will be maintained. Horsepower requirement will be about the same as before.

Weight of gas to be handled by the ID fan is again reduced because less fuel is being burned. However, leakage allowance for the air heater has increased weight of gas to be handled to a quantity slightly greater than that originally required at full-load boiler condition. Static pressure requirement was determined by correcting system resistance for the lower temperature as well as for the smaller volume of gas, and adding pressure drop through air heater.

Remember that in other boiler systems, ID fan may have to be revamped as well as FD fan. Oil firing was used, in our example, which allowed temperature of air entering the boiler to be higher than 300 F. This, in turn, allowed gas temperature to be lowered to 300 F. Since gas temperature was initially 600 F and fan was designed for 650 F, the 350 F temperature reduction allowed fan to increase its static pressure considerably. Also, a big factor in allowing this fan to accommodate the air heater was that it was originally dampered at fan design condition—it was slightly over-sized.

A word of caution—it is imperative that the fan manufacturer be contacted when a speed increase is being considered. He alone will know whether or not the wheel, shaft, and bearings can take the increased speed.

Higher boiler working pressures are being used in modern boiler installations. This results in higher flue gas temperatures leaving the boiler. Because of this, it is an economic necessity to use heat recovery equipment. In larger installations, both air heaters and economizers are used. Generally, only one is used in small installations.

Naturally, there is a point where quantity of fuel burned per hour is not enough to save enough to pay for heat recovery equipment. Due to higher fuel costs, this point is gradually being lowered and should be investigated at least. The effort may prove profitable.

Why not try *SIMPLICITY* in valve controls?

CHESTER S. BEARD
Foster Engineering Company

SIMPLICITY in selection and design of control systems can save money. In this era of increasing automation consciousness and technical improvements, exact requirements for each installation must be considered individually. The simplest and often least expensive method is best.

In many cases, the simplest method of controlling a system to obtain best quality and highest speed may turn out extremely complex. Tremendous numbers of control applications, however, may be handled best by a very simple approach.

Much unnecessary work and expense can be eliminated by using a simple device for a simple application. Most of us have seen control systems with embellishments for which the expense was not warranted — where a dependable automatic regulating valve might have handled the operation adequately and economically. Before continuing with the theme of simplicity, however, we will summarize the equipment with which we are dealing.

Regulator is a primary control

Primary control device in pressure, temperature, and level control is a regulator. A regulator directly translates change in the variable to be controlled to corrective action. Though this discussion will deal with regulating equipment used to control fluids, the definition of a regulator applies equally well to electrical regulating equipment.

In a pressure regulator, controlled pressure creates a change in force exerted upon diaphragm or piston to position a valve. Float buoyancy in a level regulator is the valve-positioning force.

In temperature regulators, expansion of a gas or liquid, or the pressure created by an equilibrium between vapor and liquid phases supplies force to position the valve.

Ability of a pressure or temperature regulator to motivate corrective action depends on compression of an adjustable spring. Consequently, a finite change in controlled variable is necessary before a change in position of the main valve occurs.

Sensitivity of this device is dependent upon the relationship between spring rate, diaphragm size, main valve size, and unbalanced forces created by pressure drop across the main valve.

Broader approach to application of regulator control is possible if a pilot regulator is used to operate the piston or diaphragm of the main control valve. Although there are many ways to take advantage of the pilot system, there are two basic principles:

¶ The first consists of controlling flow to the line valve diaphragm using a constant bleed rate, either to atmosphere or back into the line (Fig. 1).

¶ The second varies bleed rate to vary diaphragm pressure supplied by a constant rate of instrument supply air (Fig. 2).

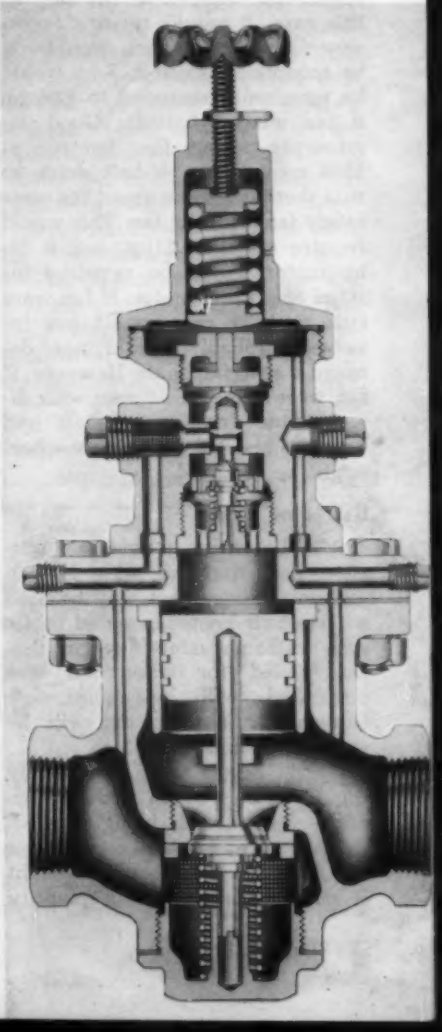
Pilot regulators broaden control application because very small control-medium flow required to move the diaphragm may be handled through very small pilot regulators. Regulators may be designed for very sensitive control.

How to select optimum control

Vast application areas requiring pneumatic or electrical control lie beyond the parameters for application of pilot-operated valves. In these systems, an instrument must be used to measure the variable to be controlled. As measurement of the variable deviates from the desired value, the control instrument puts out an electric or pneumatic impulse which varies with deviation. A value or other control unit that will respond to controller output is required to complete the control loop. Control loop is closed by measuring the effect upon controllable that changes created by control valve or control unit have caused in the controlled system.

How can you decide whether to use pneumatic control, pilot system, or direct-acting regulator? Selection may start with consideration of regulator and develop through

High-pressure line fluid exerts pressure on piston to position main valve.



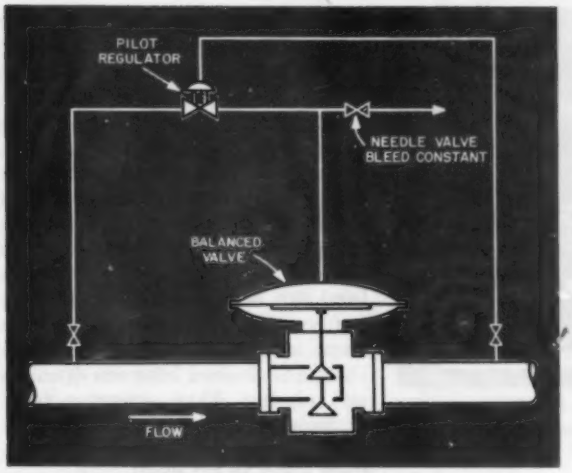


Fig. 1 - Pressure on diaphragm to position main valve is varied. Pilot controls flow above or below constant bleed.

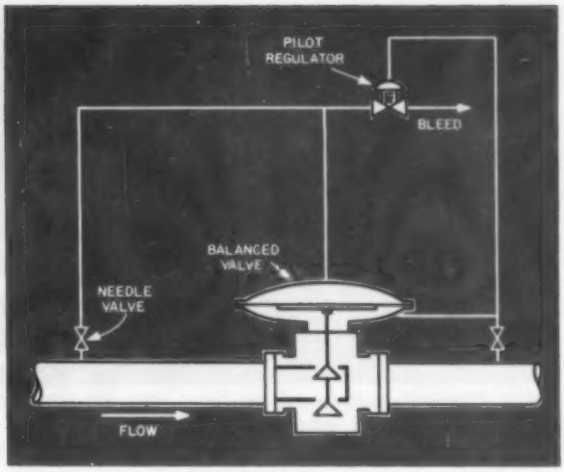


Fig. 2 - Pressure on diaphragm varies as flow is relieved by pilot regulator over or below the constant supply rate.

to controller. It may also start by determining which applications require a control system and working through to the regulator.

When to use throttling control

By the latter method, a number of applications exist which require controllers under circumstances where control may be obtained by throttling flow with a valve. To repeat, a control system is one in which change in controlled variable causes change in position of a pilot within the system controller. Pilot changes air, gas, or liquid pressure supplied to an actuator. Actuator positions the valve in direct relation to pilot output-pressure as dictated by the controller. Applications which require the use of a controller are:

a) Value of the variable is beyond pilot-system range that may be used on fluid to be controlled. Generally speaking, internally piloted piston-actuated valves will control steam pressures up to 600 psi. Pilot-controlled diaphragm-actuated valves will control gases or water up to 175 psi. Temperature valves are designed to control temperatures up to 300 F. Controllers are best for applications above these limits.

b) Variable is other than temperature, pressure, or level. It is difficult to disprove the statement that anything that can be measured can be controlled. Fortunately, orthodox pneumatic controllers will measure many different variables and many more may be transmitted using local measuring units. Examples of these variables may be: speed, which may be governed with control valve in a steam turbine line, or pH control, where the valve is in a line feeding neutralizing fluid to a vat.

c) When need is for closer control than that obtainable with a pilot system. Tests have shown that pilot-balanced valves may be considered for control of pressure to within one percent of controlled pressure setting. The diaphragm-operated temperature valve in sizes up to two inches will control to within ± 1.0 F. Piston-actuated valves are used for larger sizes, although available in sizes two inches and smaller. This unit will control to within ± 3.0 F.

Oddly enough, the governing limitation for liquid-level control systems is not one of the close control. Desire to hold constant flow at expense of level change necessitates wide throttling range controller. Level control of an interface between two liquids is also an application requiring a controller.

d) Control application requires variable throttling range, automatic reset, or derivative action. Controller with variable throttling range may be set to obtain full valve travel with wide variation from instrument set point. This same controller may be set for narrow throttling range so that a very small change in measured variable causes large valve movement. Most controllers are designed to obtain a variable throttling range for added control flexibility.

Both regulators and pilot valves have a low throttling range to obtain high sensitivity to changes Throttling range of automatic valves depends on design characteristics. It cannot be changed readily by the operator. When process being controlled has appreciable dead time, a wider throttling range must be used for stability. As throttling range increases, deviation from original set point becomes greater for a given change in operating conditions. Reset or integral response may be used, thereby continuing a corrective supply change to actuator until variable is returned to original set point.

Which controller action to use

Rate or derivative response operates to accelerate actuator corrective action. Three combinations of controller action are used, depending on process characteristics — proportional plus reset, proportional plus rate, and proportional plus reset plus rate.

One type of integral controller incorporates mechanical positioning feedback action to the controller with attendant decrease in valve operation lag. Although this action does not occur with phase relationship ahead of controller action, it brings valve action and controller

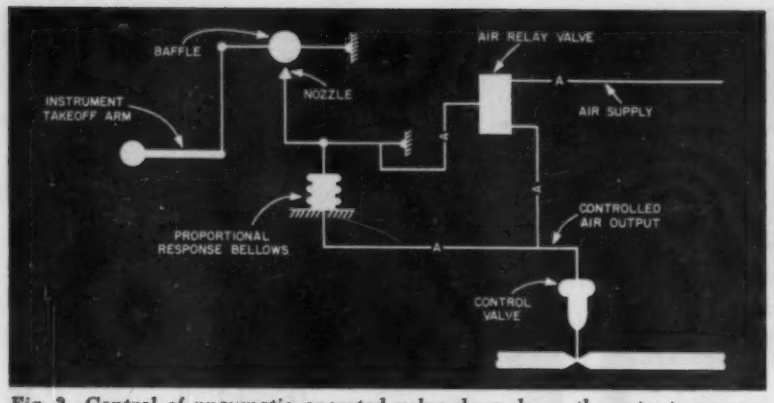


Fig. 3—Control of pneumatic-operated valve depends on the output pressure of a controller. This system is readily adaptable to remote control uses.

action back into synchronization.

e) Control of a remotely located valve is to be retained from a central control board. Placing controller in a sheltered spot facilitates servicing the instrument in bad weather. Nevertheless, there has been a trend toward controllers mounted close to or on the valve. In this case, recorded or indicated information may be transmitted to the board. Transmission lags in control systems may be reduced by using pilot-actuated valves as well as locally mounted controllers.

f) Need is for cascaded control. This special form of instrumentation requires a controller because the output of one controller is used to reset another controller.

g) Available pressure drop across control valve is insufficient to motivate the valve using pilot control. Pilot-operated valve requires 10 to 20 psi differential pressure across the seat, depending upon valve model and application. In many cases there may not be this much pressure in the system.

Remember that good control through normal operating limits requires that pressure differential across the valve seat be at least half as great as pressure drop in piping and equipment. It is difficult under any conditions to obtain good control if pressure drop through the valve is less than three psi.

Other conditions to consider

If none of these conditions requiring a controller exist, consider type of control in which a pilot valve — either pressure, temperature, or level — varies loading of piston or diaphragm to position main valve. Internal pilot-operated valves are also used for back pressure or relief service and as pump governors. External pilot valves may be used with balanced diaphragm valves to cover a wide scope of pressure applications.

In balanced diaphragm valves, the line pressure being controlled is applied to one side of the diaphragm, and reference or control pressure acts on the opposite side. Variable pilot pressure control systems assume that change in value of the variable will motivate the pilot valve. This, in turn, changes diaphragm loading pressure on the automatic line valve. Valve is positioned so that controlled variable returns to original set point.

This system can be used to advantage under these conditions:

a) When variable is beyond regulator range.

Application limit for pressure regulators is a combination of unit type, static pressure, and valve size. In very general terms, pilot-actuated valves become a consideration when set pressures approach or exceed the following:

STEAM	
Through ¾ inch	275 psig
1, 1¼, and 1½ inch	125 psig
GAS	
Through ¾ inch	250 psig
1 and 1¼ inch	200 psig
1½ inch and up	about 125 psig
WATER	
Up to ¾ inch	3000 psig
Up to 2 inch	2500 psig
Up to 8 inch	about 125 psig

Pilot-operated temperature regulators should be considered whenever temperature range is less than 300 F.

Internal pilot-operated level valves should be considered on any storage tank where level should be held to within a few inches of a given point. External pilot is used to advantage when valve is some distance away from point at which level can be measured. Pilots having vertical rod with adjustable stops are used when wide level change is desired between opening and closing. Float operates pilot at these points.

Hold close to set point

b) When it is necessary to hold variable value closer to a set point than can be done with a regulator.

Pilot system should be considered whenever pressure must be controlled within approximately three percent of set value. This is an arbitrary figure to be used when regulator type must be considered. Diaphragm-operated pressure regulators can control closer than this under proper operating conditions. High-pressure piston regulators, however, should not be expected to hold much closer than 10 percent. Increased regulating accuracy is obtained by balancing main valve. Double-seated balanced main valve may be used when lockup is not required.

Pilot operation of temperature regulators should be considered for control accuracy within a range of ±5 F.

Using characterized valve

c) When using a characterized main valve.

Pilot operation allows greater travel than can be obtained with a regulator. Main valve may be shaped—either plug or ported type—to vary relation between valve opening and flow rate. Although valve travel is not as long as in control valves, similar flow characteristics may be obtained. In most applications, control can be improved with a valve that produces slow rate-of-change at low flows with linear rate-of-change through the last half of its travel.

d) When facilities are needed for changing set point from a remote location.

Centralized control need not eliminate use of variable pressure pilot system. Pressure control from remote loading regulator may replace spring and adjusting screw (Fig. 4). A directly proportional relationship exists between controlled pressure on one side of the pilot diaphragm and loading pressure on the other side. This limits value of set point to the pressure available for loading. Use of double diaphragm head to position valve makes it possible to increase or diminish the relation between loading pressure and set pressure by ratio of the areas of the two diaphragms in the valve head.

e) When the need is for balanced level control valve.

Buoyancy is the only force available from a float. It equals weight of liquid displaced by the float. Inasmuch as most float control applications require positive valve shutoff, single seat valves are frequently used. Neither valve size nor pressure differential across valve seat need be very large to overcome positioning force. Force equals float buoyancy times float arm length.

Pilot systems extend control use

Pilot systems will broaden limits of unbalance that may be overcome without controller. Internal pilot operated by a float opens a small valve to relieve pressure holding main valve closed. It may also open a passage to allow pressure from high side of valve to be exerted on piston to close main valve. External pilots are used in numerous ways to control application of line pressure to position level valve.

f) When no pneumatic supply is available.

Pilot systems, particularly internal type, make use of line fluid to position the valve. This motivating power simplifies the system by eliminating pneumatic distribution and operating lines with attendant maintenance cost from controller.

Simply stated, pressure, temperature, or level regulators are used when pilot system or automatic controller are not required.

This would seem to relegate the regulator to a very insignificant position in the field of instrumentation and automatic valves. This is not so. Direct-operated regulators probably surpass other valves two to one in numbers in use. To verify this, consider a few uses that are rarely handled by anything but a regulator. Preliminary checklist gives applications that warrant possibility of using a pressure regulator such as:

a) All steam supplies to heating equipment

b) Domestic regulators on gas laterals to houses and other buildings

c) Domestic regulators on water to houses and other buildings.

d) Instrument and plant air systems

e) Liquefied petroleum gas systems

f) Back pressure control on oil wells

g) Welding gas tank discharge

h) Relief to pump suctions

i) Differential control for flow, fuel oil, and gland seals

j) Hydraulic systems to presses and lifts

k) Gas seal pressure on petroleum product tanks.

A list can also be made for temperature regulators:

a) Fuel oil storage heating

b) Domestic and industrial water heaters

c) Air duct control

d) Compressor and engine cooling systems.

A list of level control applications:

a) Cooling tower pit makeup

b) Cooling and boiler water storage makeup

c) Seal box level.

Many other applications may be listed that indicate a regulator except for the seeming necessity of closer control. This "seeming necessity" is a condition that should be examined very closely. Critical questions should be asked about application before selecting a more refined control method. Often it will be found that a pound more or less change in pressure has no effect upon operation or production quality.

Is precise control necessary?

Variation in temperature of a few degrees can simplify control considerably and make no noticeable change in drying time. Fuel oil evaporation from storage or cooling tower efficiency will not usually be affected by change in level of a few inches.

Suitable automatic valves are available in large variety for each application from regulator to control valve. Anyone selecting control equipment should make every effort to fit method to application with the simplest approach available consistent with accuracy.

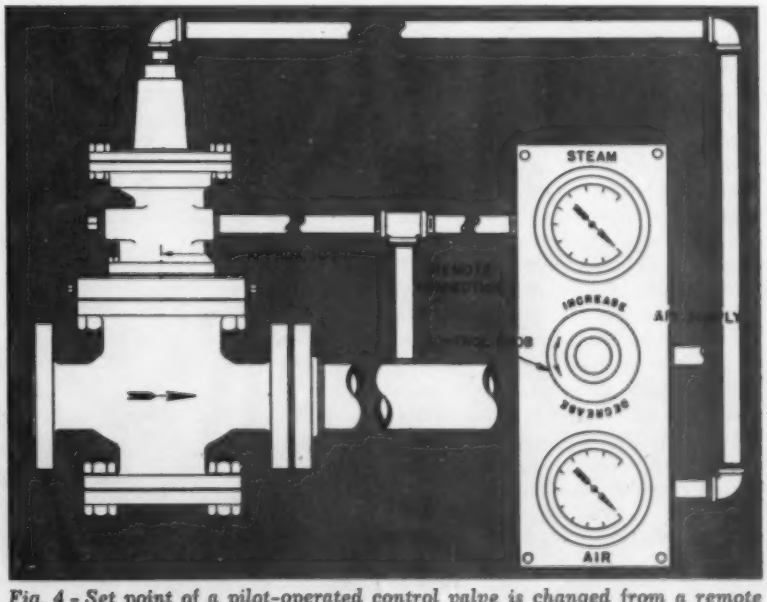


Fig. 4 - Set point of a pilot-operated control valve is changed from a remote control point by replacing the spring loaded head with a pneumatic chamber.

Part 1

Fundamental Concepts

G. C. BLALOCK
Professor of Electrical Engineering
Purdue University

Grover Cleveland Blalock is nearing 40 years full-time service on the faculty of the electrical engineering department of Purdue University. In that time, he has written several books on fundamental aspects of electrical engineering. Before joining Purdue, Prof. Blalock had been associated with Dominguez Land Co., Los Angeles City Engineer's Office, and Westinghouse Electric Corp.

MATTER OF all kinds consists of atoms or groups of atoms called molecules. Atoms comprise a *positively* charged nucleus around which tiny *negative* charges, called *electrons*, move at high speed. Physical characteristics of various kinds of matter are determined by number and arrangement of electrons in their atoms.

Normally, positive charge of the nucleus is exactly balanced by the negative charge of the electrons around it, so that the atom is electrically *neutral*. But if, in one way or another, some of the electrons are removed from a particle of matter, this balance is disturbed. Then the particle exhibits positive-charge characteristics. Negative characteristics are exhibited following *addition* of electrons to a particle. Electric charge, therefore, represents an unbalance due to an excess of one kind of electricity—positive or negative—over the other. Since like charges repel and unlike charges attract, there is constant tendency toward restoration of the neutral state.

Practically all of an atom's mass is in the nucleus, but little of its volume is there. Hence, there is much free space within the atom for electron movement. Electrons moving in orbits near the nucleus are bound more rigidly to these orbits than those moving in orbits at a greater distance from the nucleus. Outer electrons may be more easily removed from the atom. There is a marked difference between materials as to the rigidity with which their electrons are held to normal orbits.

Practical unit of electric charge, from the quantity standpoint, is the *coulomb*. It has a value of approximately $2\pi \times 10^{18}$ electrons. One electron therefore carries a charge of 1.59×10^{-19} coulomb.

Electrons of *conductor* materials are held less rigidly to their normal orbits than are electrons of other materials. Mobility of the electrons constitutes a measure of *conductivity* of materials. When heated, some materials may be caused to lose electrons through a process analogous to evaporation of water. To maintain a continuous outward movement of electrons, however, some means must be provided for drawing discharged electrons away from the heated material as fast as they are emitted. Otherwise, saturation effect is produced in the immediate region. Process is re-

Gould-National Batteries, Inc.

Primary storage battery cells provide power to raise bridge 120 feet.

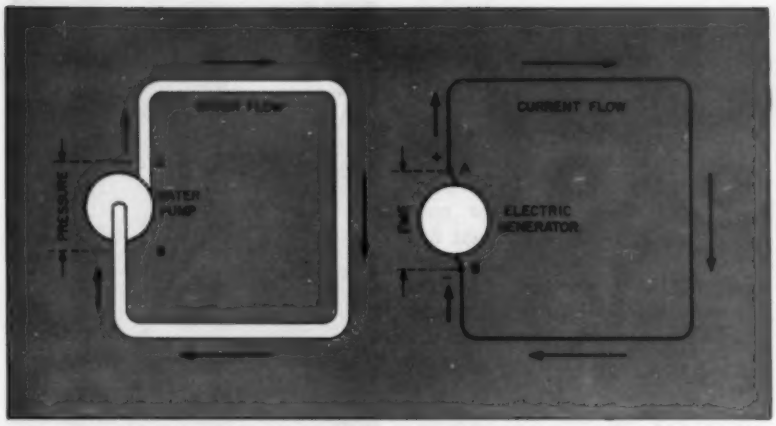


Fig. 1—Analogy can be constructed between water flow and electric current flow. Pump (or generator) forces water (or electric current) through flow path.

tarded by accumulation of emitted electrons repelling those yet trying to be emitted.

Electron emission may be brought about by other means, such as light falling upon light-sensitive materials. To maintain continuous movement of electrons in any event, a conducting circuit and a motivating *potential difference* must be provided. Movement of electrons impelled by potential difference constitutes an *electric current*. Such current flow consists of relatively slow electron movement, sometimes referred to as "drift," of free electrons along the conductor and around the circuit provided. But while actual rate of individual electron movement in a definite direction is quite slow, the *impulse* through the conductor from end to end resulting from application of *electromotive force* is practically instantaneous. Current flow begins at once at all points along the conductor. Flow rate equal to one coulomb per second constitutes current flow defined as an *ampere*.

Conventional direction of current flow is from positive to negative—from high potential to low potential. This convention is at variance with modern concept of current flow, which defines current flow as being due entirely to movement of electrons. Thus, the older convention is applied to the so-called *power circuits* while the newer concept is applied to electron tubes and their associated circuits.

Devices such as electric batteries and generators have ability to establish and maintain potential differences between two points in a circuit of conducting material. They develop electromotive force, which has the effect of maintaining one terminal of a circuit at higher potential than the other terminal. This causes current to flow as long as the circuit is complete through the conducting material, and the potential difference is maintained.

Basic analogy

Electric and hydraulic circuits are analogous in many respects, as indicated in Fig. 1. A water pump maintains pressure difference between two ends of the connecting pipeline. An electric generator maintains a potential difference between terminals connected by suitable conducting material. Terminal A is at higher pressure in the first case and at higher potential in the second case.

In the hydraulic circuit, pipe friction opposes water flow. Rate of flow is established by pressure overcoming friction. In the electric circuit, there is a corresponding opposition to current flow — resistance of the circuit. Rate of current flow (number of amperes flowing) is established by the generator electromotive force overcoming electrical "friction" in the circuit. These are not very practical setups, however, since no useful work is being done in either case. In order that useful work be done, a hydraulic device of some sort is needed in the pipeline. Electric "load," such as electric lights or a motor, is needed in the conductor line.

Great differences exist between materials as to the readiness with which electric current passes through them. In general, metals are good *conductors*, offering relatively low resistance to current flow. Glass, porcelain, and rubber are very poor conductors, having such high resistance to current flow that they are *insulators*. Some materials are in the midrange between conductors and insulators. They have useful properties for special purposes.

Copper is the most extensively used conductor material for electrical wiring. It is often encased in insulated material. Hard-drawn copper is generally used for long outdoor spans because of its high tensile strength. Insulation on the wires is not usually considered necessary for this usage, but conductors must be kept from contact with poles or towers by supporting insulators of glass or porcelain. Aluminum is also used to a limited extent because of its lightness, although it has neither the tensile strength nor conducting ability of copper. Copper-clad steel conductors are sometimes used for long spans on transmission lines.

Electric circuit is a term applied to the continuous conducting path carrying a current. It includes source of electromotive force (battery or generator) as well as the *load*, which may comprise heaters, lighting, or motors. Conductors connecting source of electromotive force to load may be a few feet long or may be many miles long.

Principal properties

Electric conductors and circuits, in general, have three principal properties—each having an analogy to properties of commonly used mechanical devices:

Resistance of a conductor or circuit opposes flow of current. It is very similar to *friction* in mechanical devices.

Inductance, on the other hand, does not oppose current flow but does oppose *change* in current flow. This is especially evident when circuit includes a coil wound upon a core of magnetic material. Inductance is analogous to *inertia* in mechanics, and is sometimes called

the inertia of the electric circuit.

Capacitance is the property of a circuit by which it stores electric charge. Capacitance gives a circuit the effect of *elasticity* — as though it contained springs that could be compressed to store energy. Capacitance effect is accentuated by *capacitors*, or *condensers*.

While all circuits exhibit these three properties in varying degree, resistance is the one normally of greatest importance in connection with dc circuits.

Resistance varies

Current flow through a circuit is always opposed by resistance, though the specific resistance of different materials varies considerably. Resistance of conductors made from a given homogenous material varies directly with conductor length and inversely with conductor cross section. *Specific resistance* or *resistivity* — designated by the Greek letter ρ (rho) — of the material is the resistance per unit length and per unit cross section. Resistance of a given piece of material is expressed as

$$R = \frac{\rho L}{A} \qquad (1)$$

where L is the length of conductor and A the cross section area. Units used for L and A determine the value of ρ for a given material. Common practice expresses L in feet and A in circular mils.

Circular mil is a unit convenient to express area of conductors having a circular section. With diameter expressed in mils (thousandths of an inch), area in circular mils is obtained by squaring the diameter.

This avoids the awkward π factor.

When diameter is given in inches, equivalent mils are given by moving decimal point three places to the right. Squaring this quantity gives cross sectional area in circular mils.

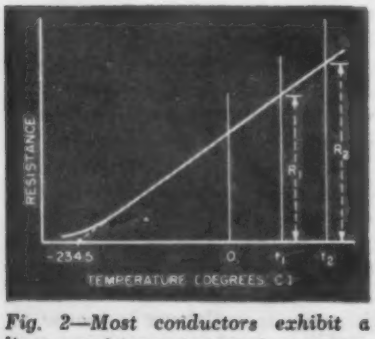


Fig. 2—Most conductors exhibit a linear resistance-temperature curve.

Temperature affects resistance of conductor materials. As may be seen from Fig. 2, variation of resistance with temperature for pure metals is essentially a straight line within ordinary temperatures. If projected as a straight line, the curve for standard annealed copper would reach zero at a temperature of –234.5 C. Assuming straight-line variation and referring to the similar triangles of Fig. 2, the following proportion may be used:

$$\frac{R_2}{R_1} = \frac{234.5 + t_2}{234.5 + t_1} \qquad (2)$$

Assuming t_1 equal to 0 C, Equation 2 reduces to

$$R_2 = R_0 (1 + a_0 t_2) \qquad (3)$$

where a_0 is the temperature coefficient of resistance at 0 C, and has the value 0.00427 for standard copper conductor material.

Metals used as conductors in general have a *positive* temperature coefficient. That is, resistance increases with temperature. Most nonmetals (such as carbon, gases, and many insulating materials) have a *negative* temperature coefficient. Their resistance decreases with rising temperature.

Value ρ in Equation 1 is defined as ohms per foot per circular mil or ohms per *circular mil-foot*. For standard annealed copper, ρ has the value 9.56 at 0 C or 10.37 at 20 C. For materials often used in heater coils, the value of ρ is much higher, reaching values around 600 ohms per circular mil-ft.

Designate wire sizes

American wire gage is commonly used to designate wire sizes. Gage numbers extend from 40, the smallest, to 0000, the largest size. Sizes vary in progression such that the cross sectional areas approximately double at intervals of three in the size scale. No. 7, therefore, has a cross section practically double that of No. 10. Sizes larger than 0000, usually cables, are designated directly by area in circular mils. Along with the gage number, standard specifications give diameter and cross section of conductor plus the resistance and weight per 1000 feet.

Usually associated with wire tables is a table of allowable current capacities for various wire sizes when used in conduit with certain specified insulations. This data comes from the National Electrical Code, which is based upon recommendations and regulations approved by the National Fire Protection Association.

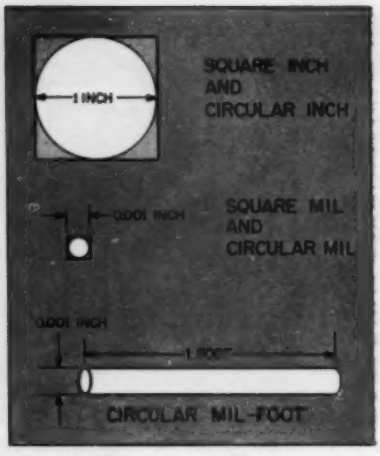


Fig. 3—Units of measure for wire are based on these configurations.

Units of measure

In commonly used, international system of units, *volt* is the unit of electromotive force. *Ampere* is the unit of current flow. *Ohm* is the unit of resistance. *Watt* is the unit of power. Closely associated with these more common units is *coulomb*, the unit of electric charge; *henry*, the unit of inductance; and *farad*, the unit of capacitance. Prefixes *kilo-* and *micro-* are sometimes used to designate values 1000 times or 0.000001 times those of the basic unit. Hence 1000 watts equal one kilowatt, and 1 million microfarads equal one farad.

Power is the rate of doing work or the rate at which energy is expended. Energy is the product of power and time. Unit of work or energy is the *watt-second*, the energy of one watt supplied for one second. Larger units derived from the watt-second are the watt-hour and the *kilowatt-hour*. Kwh is commonly used as the energy unit in power circuits.

When current flows through a conductor, electric energy converted into heat is proportional to the resistance of the conductor, to the current squared, and to the length of time the current flows.

Basic instruments are voltmeter and ammeter. Operation is based upon the principle that when a current-carrying conductor is located in a magnetic field, the conductor is acted upon by a force that tends to move it to one side. Moving effort is proportional to current in the conductor and to the strength of the magnetic field.

With a coil of conductor pivoting between permanent-magnet poles and working against light spiral springs, movement of a pointer attached to the coil may be made to provide an indication on a scale proportional to the current through the coil. Small currents may be sent directly through the coil. Heavy currents, requiring large cross sections of wire in the coil, would make the instrument less sensitive. *Shunts* are used to route all but a small portion of current sent to the meter around the coil. Instrument scales are usually marked in terms of total current measured rather than smaller current used to move the coil.

Voltmeter construction is the same as the ammeter with the addition of *multipliers.* Multipliers are resistances keeping coil currents low enough to avoid overheating and to keep swing of the pointer within scale limits. Current through the coil being directly proportional to the voltage impressed upon the combination of coil and multipler, the scale of the instrument may be marked in terms of the volts being measured.

Regardless of its use, with or without shunts or multipliers, a given current through the coil will cause the pointer to swing to the same point upon the scale. But the significance of this indication, in terms of the quantity being measured, may differ widely as indicated by the scale markings or as brought about through use of multiplying factors applied to scale readings.

Permanent-magnet type instruments are "polarized." They read upscale only when current through the coil is in a certain direction with relation to the polarity of the magnetic field. Another type has no permanent magnets, but depends upon induced magnetism set up in light iron vanes. Turning effort is independent of coil-current direction, and polarity markings are not required.

Next Month: Professor Blalock takes up some basic laws, circuits, and magnetism.

Franklin and Electricity

Kant once remarked that Benjamin Franklin was a new Prometheus who had stolen fire from heaven. In his own day, Franklin was celebrated throughout all Europe as the world's foremost electrician. His book on the subject was in demand in many countries. Far-reaching in its influence, the book became an important text in the electrical field. Even today we still write of electricity in terms introduced in print by Franklin. Used in the electrical sense, probably for the first time, in his book were words such as *armature, battery brush, charged, charging, condense, conductor, discharge, electrical fire, electrical shock, electrician, electrified, electrify, Leyden bottle, minus, negative, nonconducting, nonconductor, nonelectric, plus, positive* and others.

Franklin's book, titled *Experiments and Observation on Electricity,* was published in several editions and was read and admired in all parts of Europe. He presented his findings for both layman and specialist, and tried to remove all mystery and obscurity from electricity. His book was composed of letters and papers extending over a period of 20 years, during which time Franklin added conclusions and footnotes to his writings to change original theories and explain why he had at first been misled. For instance, in an early edition of his book he thought that lightning followed the shortest path and melted metals by "cold fusions," while he later mentioned that lightning followed the path of "least resistance," and melted metals in the normal way by heating them to their melting points.

Later conclusions as contrasted with earlier ideas of Franklin have furnished the reader with a valuable document. He not only encounters Franklin's descriptions of his experimental and theoretical discoveries but gains an idea of the history of the development. Speaking of the footnoted additions Franklin said, "In going on with these experiments, how many pretty systems do we build, which we soon find ourselves obliged to destroy! If there is no other use discovered of electricity, this, however, is something considerable, that it may help to make a vain man humble." (Letter to Collinson, August 14, 1747.)

In the preface of the first edition of his book Franklin stated, "It has, indeed, been of late the fashion to ascribe every grand or unusual operation of nature, such as lightning and earthquakes, to electricity; not, as one would imagine from the manner of reasoning on these occasions, that the authors of these schemes have discovered any connection betwixt the cause and effect, or saw in what manner they were related; but, as it would seem, merely because they were unacquainted with any other agent, of which it could not positively be said that the connection was impossible."

Franklin's influence and fame as a tamer of lightning and contributor of electrical experiments reached from America to England and the continent. The Royal Society awarded him the Sir Godfrey Copley Gold Metal in 1753 and later elected him a member of the Society due to his observations on electricity.

. . . . courtesy of
The Franklin Institute

In brief....

Plant Maintenance Conference

FIFTY SESSIONS on 26 aspects of industrial maintenance highlighted the seventh annual Plant Engineering & Maintenance Conference in Philadelphia last month. Some 2500 engineers attended the Conference. Some 20,000 industrial executives toured the Plant Maintenance and Engineering Show, which ran concurrently. About 400 companies showed some 5000 different products and services.

Design and operation of maintenance shops

J. E. Baltzell, Jr.
Maintenance Shops
Middletown Works
Armco Steel Corp.

"We have found that the following phases are most essential to operations of maintenance shops:

"Phase 1—Authorizing of maintenance work:

"Execute the work order before the work is undertaken! A work order form is important. Many times the true intent of this form is quite forgotten in the rush of day-to-day work. We frequently find description of the equipment inadequate, as, 'make necessary repairs to pump.' Many say we are too busy to worry about these details. But by watching them we have, first, a better organization of the work and improved maintenance service; and second, longer-range maintenance plans which are better coordinated with existing production schedules.

"Phase 2—Proper planning and scheduling to raise our maintenance efficiency, providing:

"a) Adequate preparation — which includes tools, parts, material, and craftsmen;

"b) Formal instructions to workers as to their order of work for following day or days;

"c) Proper tie-in between crafts;

"d) Proper job priority so that equipment downtime is kept at a minimum;

"e) Insurance that all jobs, large and small, are completed, once they are started. . . .

"Planning that can anticipate 80 percent or more of the work a day ahead we have found to be good. . . .

"4. Establish job priority by date wanted, not by 'No. 1 Priority,' 'Rush,' or 'Soon as possible.'

"5. Plan work so that a day's work in advance is laid out for each craftsman each day.

"Phase 3—Preventive maintenance problems are more adequately dealt with.

"Phase 4—Workload measurement. Where overloads exist, we do several things: renegotiate 'date wanted' to future weeks; get approval of overtime; increase number of craftsmen; or subcontract some of the work.

"Phase 5—Maintenance stores control tied in closely with preventive maintenance and vital spares programs.

"Phase 6—Better relations with production departments and maintenance. Good relations are essential because they have an effect and bearing on the morale of people in all departments, the ability to meet production schedules through having a well-maintained plant, and the ability carry out maintenance plans successfully from start to finish of each repair or addition as it is needed."

Technical aspects of maintenance painting

Fred B. Leitzsey
Planning and Design Group
Bureau of Yards and Docks
Department of the Navy

"The trend in industry toward the use of specification paints is increasing irrespective of the utopian claims of some producers who state their products are superior to all others. The perfect all purpose paint for all surfaces under all conditions is but a theoretical dream. The testing and evaluating of one 'trade name' product against another has not proved satisfactory (except where such paints are both formulated and applied in accordance with specific chemical and physical requirements). The Navy requires the use of specification materials wherever practicable. The use of specification materials assures consistency and affords protection against probable changes in formulation as can be encountered in 'trade name' products. . . ."

Maintenance painting policies

Carl J. Ebert, Manager
Facilities Branch
Maintenance Division
Bureau of Yards and Docks
Department of the Navy

"There are several factors which govern the 'why' of maintenance painting. At the risk of seeming elementary, I will review them.

"1. To protect and preserve. Usually, this type of painting is necessary to prevent the rotting of wood, the corrosion of metal, and in some cases, to render porous masonry weathertight.

"2. To provide a clean and sanitary environment. . . .

"3. To effect good visibility. We can increase the efficiency of artificial light sources tremendously by using white or light-tinted paints. This is particularly true in spaces where outside light is limited. On the other hand, if it is necessary to reduce reflection and glare from the exterior, the use of dark colors having nongloss surfaces is most effective.

(continued on page 64)

Only Chapman Tilting Disc Check Valves give you

FAST TIGHT QUIET CLOSURE

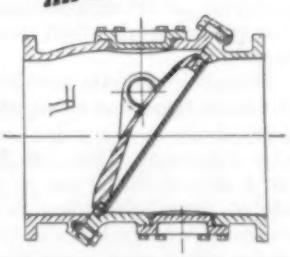
Fast, quiet operation means low cost operation for check valves. That's exactly what the Chapman Tilting Disc Check Valve is designed to do. It won't flutter or slam and damage the piping joints or the valve itself. The unique drop-tight closure action eliminates scraping and wear of the disc and seat.

Rugged construction and low wear of the Chapman Tilting Disc Check Valves mean long life under severe operating conditions. Absence of vibration plus low head loss keep maintenance of the entire piping system at a minimum.

Whether for replacement or for new piping systems, be sure to specify Chapman Tilting Disc Check Valves. They're available in iron and steel for handling fluids or gases under a wide range of pressures. For full data on the complete line, write today. Ask for Catalog 30-A.

The Chapman Valve Mfg. Co.
INDIAN ORCHARD, MASSACHUSETTS

Here's why Chapman's Tilting Disc Check Valves Keep Quiet All of Their Lives



This specially designed "airfoil" disc balances perfectly in open position. The fluid holds the disc tightly against its stops without flutter. The body of the valve is larger around the disc, so the net valve area is at least as much as the pipe area to assure low flow resistance.

When the flow is reversed, pressure against the upper part of the disc cushions it as it closes. Then the disc drops easily and tightly to its beveled seat after the valve has swung closed. Seating is fast and quiet with minimum head loss in all but unusual piping arrangements.

Circle 138 on READ-N-CIRCLE card for more data

Plant Maintenance Conference

. . . starts on page 62

"4. For safety and efficiency. In common with industry, the Navy is conscious of the necessity for providing visual warnings of hazards, particularly at its industrial activities. For a number of years, a uniform system of painting for safety and efficiency has been followed. By the judicious use of certain vivid or contrasting colors, accidents have been materially reduced, morale improved, and production increased.

"5. To improve appearance. Painting for appearance alone is done only on a limited scale today. The necessity for confining maintenance expenditures to the minimum necessary for economical operation limits such painting to comparatively few areas. It is done in such cases only where it can be justified on the grounds of maintaining morale and effecting 'good housekeeping' practices."

Planning and scheduling for effective control

Stuart Whitehead
General Superintendent
Maintenance and Construction
Calco Chemical Division
American Cyanamid Co.

"To appreciate some of the problems involved. . . . let us look briefly at the type of work which must be integrated. . . .

"1. The daily routines: The daily routines represent those jobs which are done on a regular and repetitive frequency. They can be done on a shift-to-shift basis as in the case of some lubricating procedures; on a weekly basis in the case of the steam trap inspection; or a yearly basis in the case of insurance inspection of insured tools. . . .

"2. The type of work called running repairs: This work can best be described as a routine type of work with no predetermined frequency. In a sense it is routine and also preventive in nature. Such things as the regular patrol that a mechanic may make daily to tighten up various leaks which may have occurred on the packing glands of the valves, pump packings, the repair of leaks, product, steam, etc. This will be defined as a type of work which has no regular occurrence frequencies and are jobs not on our routine schedule that are less than four man-hours in duration. This represents 16 percent of our total maintenance workload.

"3. Preventive maintenance work: It could easily be argued that the routine work is preventive maintenance, and in a sense this would be correct. However, the implication of preventive maintenance work has a considerably deeper meaning than the routine inspections and cleanings which we recognize under routines and the minor repairs described under running repairs. The chief difference, in my opinion, is the creativity necessary to reduce the occurrence or eliminate the need for performing the job at all. In this area we are in the field of maintenance engineering, metallurgy, electrical engineering, and a deeper and broader field.

"4. Long-range workload, including an inside and outside paint program, road repairs, building interiors, plant fences, and landscaping—some of which may be seasonal work done yearly, semiyearly, or quarterly. Certainly planned shutdown which can be anticipated falls in this general area. Items 3. . . . [and] 4 represent approximately 52 percent of the total maintenance workload.

"5. Production changeovers, for purposes of setting up new production lines or rearrangement of equipment for running various products in existing equipment. This is certainly not maintenance but necessary work that must be done with maintenance employees. This represents about three percent of the total maintenance manhours.

"6. Minor improvements, which includes those noncapitalized jobs including safety improvement of convenient items. This is about three percent of the total maintenance man-hours.

"7. Breakdowns: This needs no explanation. Less than one percent of the total maintenance manhours."

Yardsticks to measure effectiveness of maintenance

R. I. Reul
Food Machinery & Chemical Corp.

"Properly compiled and accurately recorded over long periods of time, historical records of actual true direct maintenance expenditures can be demonstrated to be one of the best bases for evaluating overall maintenance performance.

"To be useful for this purpose, the costs recorded should include *all* true, and *only* true, directly allocable maintenance costs. They should be segregated both by equipment groups and by cost centers. From these data, production records, plus some idea as to the nature of the work done (which can be learned from perusal of individual work orders applicable), it should be possible in most cases to make a pretty shrewd guess at how these costs vary. They will vary with calendar time, operating time, thru-put or some combination of these factors. Often approximation of these relationships by graphical methods will suffice.

"If equipment, labor rates, material prices, and effectiveness of maintenance continue unchanged, we can expect that *on an average*, maintenance costs should rather closely follow past experience.

"By keeping our costs segregated by equipment groups, we can allow for equipment changes. Variations due to changes in labor rates and material prices can be compensated for by use of available index factors. The only remaining factor is maintenance effectiveness. It is, therefore, reasonable to assume, unless proven to the contrary, that any remaining variance from past pattern is due to a change in the effectiveness."

From Regina to Saudi Arabia

B-L VESSEL LININGS SET RECORD AFTER RECORD FOR DEPENDABLE PERFORMANCE

It looks like a Cook's Tour—but it isn't. Instead it's a listing of recent Bigelow-Liptak refinery installations in far-flung corners of the world.

There are good, solid reasons for this world-wide preference for Bigelow-Liptak jobs. In the first place from B-L's years of experience has come a *complete castable package*. Insulating- and abrasion-resistant castables are *engineered, furnished* and *installed* by the same company—which means just one contract and one responsibility.

The overall result of this all-in-one engineering is exceptional durability and performance. B-L refractory installations have established world records for continuous operation. For example, after initial runs of 785 and 610 days, B-L linings were in perfect shape—required no repairs during shutdowns.

Yes, from Regina to Saudi Arabia—and points in between—Bigelow-Liptak installations are setting new records for service and performance. For complete information write for the B-L catalog "One Source". Do it today!

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• Batangas, Philippines	Regenerator and Cyclones
• Yokohama, Japan	Regenerator and Cyclones
★ Ras Tanura, Saudi Arabia	Regenerator—Reactor
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• Anacortes, Washington, U. S. A.	Regenerator, Reactor, Cyclones and Lines.

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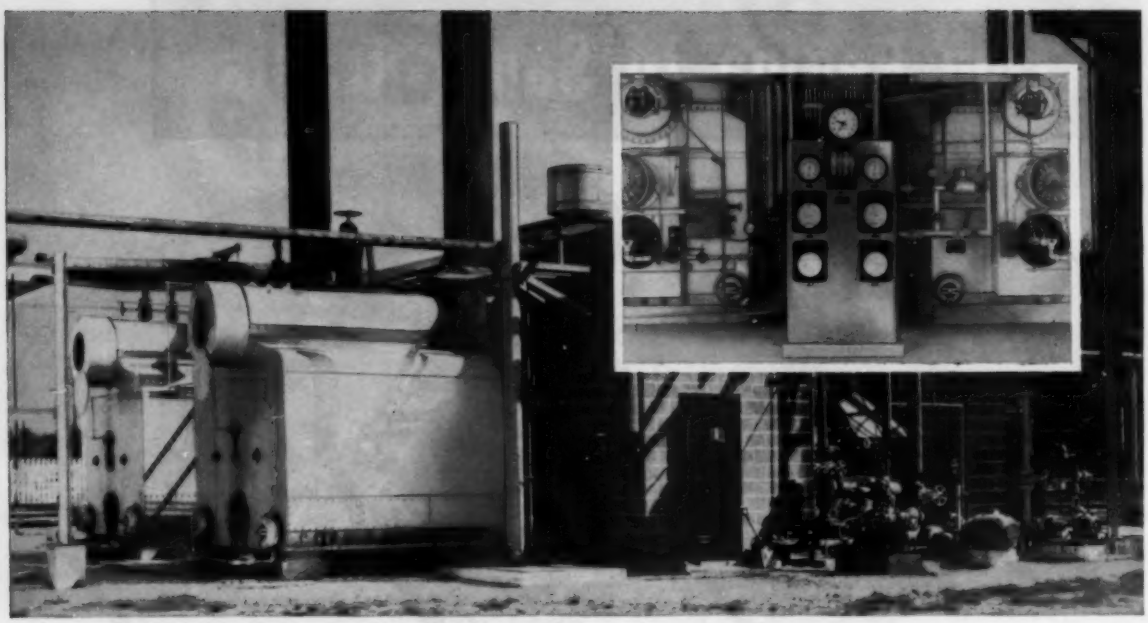


Two Union packaged boilers play important role in Davison cracking catalyst plant

Job Report (UIW) — Proving that they can do their job outdoors as efficiently as indoors, two Union Type MH Steam Generators handle a key assignment for Davison Chemical Company, Division of W. R. Grace & Co. They deliver process steam in Davison's large Lake Charles, La. plant which is equipped to produce approximately 45,000,000 lbs. of petroleum cracking catalysts annually.

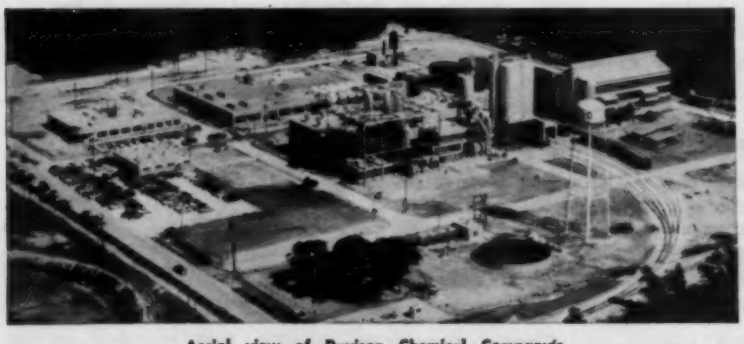
Selected for this important role because of "reputation . . . and delivery," these Union Packaged Steam Generators are reported by Davison to be operating at high efficiency.

Each of the pair has a steam capacity of 18,000 lbs/hr. at 250 psi and is gas fired. Both were completely assembled in Erie, Pa. by Union Iron Works before delivery to their Louisiana job site.

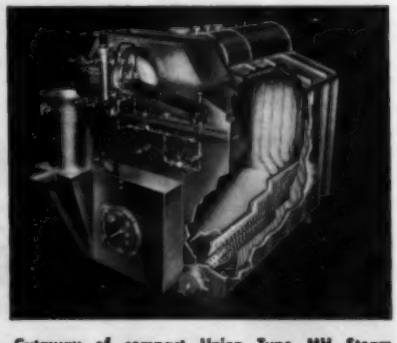
Patterned after larger but similar field erected Type H Boilers, originated by Union over 16 years ago, numerous MH Packaged Units are being installed in chemical processing plants, pulp and paper mills, breweries, refineries, institutions, schools and hospitals.

With standard units designed in 13 sizes from 10,000 to 40,000 lbs/hr. at 250 psi, Union Packaged Steam Generators can be equipped to handle multitudes of needs formerly requiring costly field erection. For example: Superheaters can be installed to meet total temperature requirements, while air heaters and economizers are readily supplied when needed. High pressure units are also available for special applications.

The complete story of Union Type MH Steam Generators, including cut-away illustrations, tube layouts and dimension tables, can be obtained promptly by requesting Bulletin MH-353 from Union Iron Works, Erie, Pa.



Aerial view of Davison Chemical Company's large Lake Charles, La. plant for manufacture of petroleum cracking catalysts.



Cutaway of compact Union Type MH Steam Generator. Tubes arranged for straight-through gas flow with low draft loss.

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Refractory castables stand up

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spot news

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● More copper, more aluminum this year

It is expected that a balance between supply and demand of copper will be reached during the first three months of this year. There may even be a slight surplus of copper by July. Development of new mining properties and expansion of existing mines—both long-term projects —will bring increasing amounts of copper to market. Copper output is expected to increase monthly, at least for the next three years.

More aluminum will be used this year than ever before, according to R. S. Reynolds, Jr., president of Reynolds Metals Company. Domestic producers supplied an estimated 3.1 billion pounds of new primary production during 1955—setting a new record for the fourth successive year. Supply outlook for 1956 indicates another high, with added facilities bringing production up to 3.3 billion pounds. Aluminum shipments to American industry during last year were about 35 percent higher than in 1954 and are still increasing.

● Similarities in gas turbine combustion

Mathematical similarity analysis technique is potentially useful for solving complex combustion problems, according to Albert E. Weller of Battelle Institute. However, few significant results have been obtained with it to date. Intensive research effort has been directed toward combustion phenomena in recent years, but cost considerations have limited full-scale experiments that would give desired data directly. Combustion technologists have sought to apply similarity techniques to combustion problems. Thus, research workers could relate behavior of physical models to their full size counterparts, and to obtain more information from a given experiment. But similarities have not been as productive as might be expected and have yielded ambiguous results under certain conditions. However, technique may prove fruitful in future combustion research. A set of critical, benchmark experiments might supply data that would lead to a better understanding of scale effects on combustors. Such data might also allow scaling procedures to be developed for combustion systems.

● Flyash used in suspension bridge

Flyash that meets high quality specifications (marketed under trade name of Alfesil) is a principal ingredient in 440,000 cu yd of concrete being poured for the $100 million Straits of Mackinac bridge. All concrete for 34 foundation piers that will carry the 66,500-ton load of superstructure is being placed by the Prepakt method. This concrete results from filling voids in coarse aggregate with intrusion mortar. After coarse aggregate has been placed in forms, intrusion mortar is pumped into voids either through the forms or through pipes placed within aggregate. In addition to portland cement, sand, and water, the intrusion mortar contains Alfesil and an intrusion aid. Alfesil is a finely divided siliceous pozzolan, in which category certain high-grade flyashes are included. It is not a cementing material by itself. Flyash reacts with lime liberated by hydration of cement to form insoluble strength-producing compounds. Reduction in cement content of 30 to 50 percent is possible because of this reaction. Lime-flyash reaction also greatly reduces permeability at later stages. Flyash particles separate cement grains in the fluid mortar and delay initial set. Being spherical, they improve mortar's flow characteristics. Prepakt method uses a much higher proportion of flyash than is generally permitted and used in conventional concrete.

● Waste pickling liquor project is cooperative

Eight major metallurgical companies will cosponsor a demonstration plant expected to solve the old problem of treating and disposing waste pickling liquors from steel operations. Cooperative undertaking by Blaw-Knox Company, Jones & Laughlin Steel Corporation, National Steel Corporation, Pittsburgh Steel Company, Republic Steel Corporation, United States Steel Corporation, Wheeling Steel Company, and Youngstown Sheet and Tube Company will use a new process to regenerate pickling solutions. Semicommercial unit, rated at 650 tons of sulfuric acid per year, will be built on Republic Steel Corporation's site at Niles, Ohio. Initial operation is scheduled for late summer. Basic reactions for the process were discovered by an Austrian scientist and have been developed by Blaw-Knox Company. Entire sulfate equivalent of waste pickling liquor is regenerated as fresh sulfuric acid for reuse in steel pickling. Iron in the pickling solution is recovered as essentially pure iron oxide, which is then recharged to the blast furnaces for use.

● Last year's review

Electric generation by utilities during 1955 totaled 545 billion kwh, an increase of 73 billion over 1954. Another 78 billion kwh were produced by industrial and railway plants, bringing the grand total to 623 billion kwh. This is over 40 percent of all electricity produced in the world. . . . Construction figures resumed their long upward march in November after dipping slightly in October. November grand total was 20 percent over November of last year, according to F. W. Dodge Corporation. . . . General Electric Company produced mechanical drive turbines totaling 180,000 hp last year. Turbogenerators with over 40,000 total kw capacity were also produced by the Small Turbine and Supercharger Department. . . . Record high shipments of over $42.5 million were reported by Reliance Electric & Engineering Company. Reliance's backlog of orders increased during the year from $11.5 million to over $26 million. . . . Consumer demand for petroleum swept past 3 billion barrels in 1955. Total of well completions increased 6.6 percent during the year, but number of gas wells declined 9.4 percent. Operable refinery capacity increased 114,000 barrels/day to 8,535,000. Distillate fuel oil output

increased 60 million barrels to a total of 602 million barrels. Residual fuel oil output increased from 417 to 418 million barrels. Yield of residual fuel oil continues to decline because of the necessity for refiners to concentrate on production of lighter products. As a result, total demand for fuel oil exceeded total supply although last year's output was an alltime peak. . . . Sales of plastics and synthetic resins hit the 3.5 billion pound mark—a gain of more than 35 percent over 1954. Chiefly responsible for the boost was the family of vinyl plastics, which sold 650 million pounds for the year. Bulk of the production went into established uses where plastics have replaced traditional materials.

● This year's preview

Electric manufacturing industry expects to surpass last year's output by 7½ percent in 1956. Total industry output will reach $18.7 billion. Output of electric industrial products such as motors and controls, welding equipment and wire, carbon products, industrial electron tubes and metallic rectifiers is expected to increase 6 percent to $2.4 billion. . . . Steel production during first half of this year will be highest in history, although indications are that most steel products will remain in short supply. Tightest products will be plates, sheets, strip, structurals, and certain bars and tubular products. . . . Nickel will remain in short supply and will limit production of nickel-bearing alloys (including stainless steel) below the growing demand. . . . New construction expenditures for this year are estimated at $44 billion—5 percent above last year. . . . Backlogs of industrial construction are approaching the highest levels since the earlier part of the Korean War. Rate of industrial construction may exceed last year's by as much as 15 to 20 percent. . . . Total capacity of electric generating units going into service before June will be far below the production of 3.75 million kw. This is a result of strikes at Westinghouse Electric Corporation's plants. However, 12 million kw will be added to installed capacity, bringing the year-end total capacity to about 113.8 million kw. . . . Production of electronic products is expected to establish an alltime high around $6.8 billion at factory prices. . . . By the end of the year, automobile and portable radios will be almost wholly made with transistors instead of tubes. . . . Chemical sales up to June are estimated close to $12 billion. . . . Air conditioning sales are expected to ring up a total retail volume of about $3.2 billion. . . . Production and sales of rubber products next year will be almost as high as last year. Country will consume about 1,465,000 long tons of new crude and manmade rubber.

● Raising transmission voltage

Detroit Edison Company is studying the possibility of raising transmission voltage from its present high of 120,000 volts to 330,000 volts or more to keep ahead of increasing power use. As part of this study, installation of a relatively short section of 330,000-volt line is being considered. Eventually, higher-voltage lines would be superimposed over the company's entire 120,000-volt transmission system. Higher voltage would facilitate carrying heavier power loads imposed by population growth and increasing power use in Southeastern Michigan. Detroit Edison services 7600 square miles with a present population of about 4 million. Studies indicate population increase of nearly 40 percent in the next 20 years.

Westmoreland Coal Company

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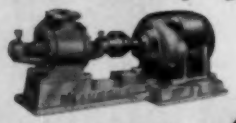

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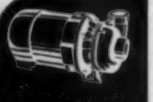

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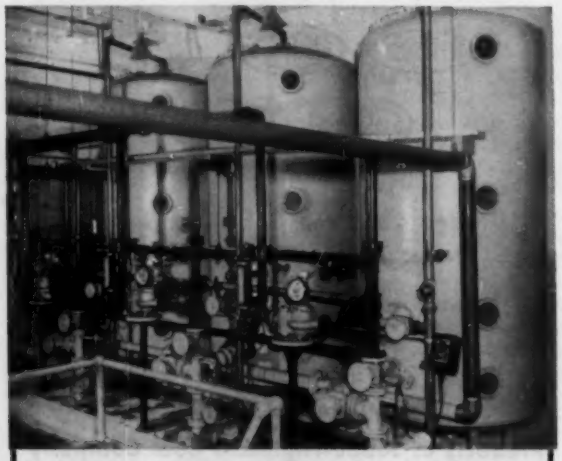

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Also a complete line of other water conditioning systems.

Write for details.

HUNGERFORD & TERRY, INC.
CLAYTON 1, NEW JERSEY

Circle 143 on READ-N-CIRCLE card for more data

spot news

. . . starts on page 92

● Schedule beat at Kyger Creek

Kyger Creek power plant of Ohio Valley Electric Corporation is now in full operation—more than three months ahead of schedule. Fifth and last of the station's 215,000-kw steam turbogenerators has been put on the line. Operation of the sixth and final unit at Clifty Creek, a sister station, is scheduled for February. Kyger Creek's Unit 5 was scheduled for next April, Clifty Creek's Unit 6 for June. OVEC has placed 2,365,000 kw capacity in operation in 12 months—a record in electric utility industry history.

● Continuous magnetic refrigerator is now available

Temperatures as low as 0.25 Absolute can now be sustained by using a magnetic cooling principle. Previously, these very low temperatures could not be sustained for any length of time because actual cooling occurred only during a brief period of demagnetization, after which heat continuously leaked in from outside the equipment. Magnetic refrigerator, made available commercially by Arthur D. Little, Inc., uses a working substance (iron-ammonium-alum), a liquid helium bath, and a reservoir cell that is to be cooled. Reservoir cell is located in chamber where experiments are conducted.

System is first cooled down to about 1.0 A by a bath of liquid helium boiling at reduced pressure. Then the paramagnetic iron-ammonium-alum is magnetized. A thermal valve, consisting of a strip of superconducting metal in the center of the control coil, conducts heat of magnetization to the helium bath. Working material, which is demagnetized after this valve is closed, cools itself. A second thermal valve opens, allowing working material to withdraw heat from reservoir cell. This cycle is repeated periodically. Reservoir and its surroundings can be kept at any desired temperature in the range from 0.25 to 1.0 A for any length of time.

● Orders in the news

Dravo Corporation has been awarded a contract to expand the water pumping and supply system at the central pumphouse at Jones & Laughlin Steel Corporation's Aliquippa Works. Two of seven 15-million-gpd pumps will be replaced with two 40-million-gpd De Laval pumps. Dravo will also supply traveling water screens, 60-inch water header, all station piping, and 42-inch pipeline to serve a new hot strip mill. Pumps will be driven by 1750 hp electric motors. . . . Baltimore Gas and Electric Co. has ordered a 125,000-kw steam turbogenerator from the Large Steam Turbine-Generator Department of General Electric Company. Turbine for the 160,000-kva generator will be 3600-rpm tandem compound, double-flow, reheat type. . . . Cleveland Electric Illuminating Co. ordered two 7000-hp, 7300-rpm boiler feed pump turbines from the Small Turbine and Supercharger Department, General Electric Company. . . . Hungerford & Terry, Inc. has received an order from Duquesne Light Co. for an ultramodern and efficient fully automatic water-conditioning plant for their new

nuclear power plant at Shippingport, Pa. Water will be taken from the Ohio River. Final treated water will be superior in quality to multiple distilled water.

● Expansions in the news

Trane Company, manufacturers of air-conditioning, heating, ventilating, and heat-transfer equipment, are planning construction of a 65,000 sq ft L-shaped engineering building. . . . Koppers Company, Inc. is planning to expand its Petrolia, Pa. plant to increase resorcinol production by 40 percent. . . . The Felters Company will spend approximately $350,000 to build a new plant and install conventional and specialized machinery for production of its recently introduced felt-like fabric, ALLFAB. . . . Installed capacity of Aluminum Company of America's two Pacific Northwest primary aluminum smelters will be increased by 11,000 tons this year. . . . T. J. Cope, Inc. and its wholly owned division, Instrof Corp., have moved manufacturing operations from Philadelphia to expanded facilities at Collegeville, Pa. Cope manufactures expanded metal trough to support power cables and Instrof makes expanded metal trough to support instrument tubing. . . . Baldwin-Hill Company has expanded manufacturing facilities at Huntington, Ind. for manufacture of mineral wool felts with great densities. . . . James Lees and Sons Company have begun manufacturing operations in their newly expanded spinning mill at Glasgow, Va. . . . Bogue Electric of Canada, Ltd. has started producing motor generator sets, magnetic amplifiers, and control systems, power equipment and water-conditioning equipment in a new 80,000-sq ft at Gloucester, Ont. . . . Air Reduction Sales Co. will build another plant—this one for oxygen, nitrogen, and argon production—in Calvert City, Ky. . . . Western Gear Corporation has started construction of a new 20,000-sq ft engineering building at Lynwood, Calif. . . . Automatic Electric Company will build a new multimillion dollar factory on a 170-acre site 15 miles from Chicago. All of its Chicago operations, now housed within 14 different buildings, will be consolidated in this one plant.

● Company lineups continue changing

Koppers Company, Inc. has acquired the assets of Industrial Sound Control, Inc., leading designer and manufacturer of noise control equipment. Company has also purchased 80 percent of the common stock of Durethene Corp., makers of polyethylene film and tubing. Altogether, Koppers acquired six different companies in 1955. . . . United States Air Conditioning Corporation has purchased all outstanding stock of Jordon Refrigerator Company, manufacturers of commercial and home refrigerators and freezers. . . . Pyrene Manufacturing Company and its wholly owner subsidiary C-O-Two Fire Equipment Company have merged and adopted a new name, Pyrene—C-O-Two Corporation. . . . Infilco Inc., manufacturer of equipment for all types of water and waste treatment, has organized an entirely new Ion-Exchange division. . . . Square D Company and Electric Controller and Manufacturing Company have begun operations as a merged corporation. Square D, as surviving company, will operate Electric Controller as a separate division. Bulk of Electric Controller's products are for custom application in heavy industries. Square D is primarily a mass-production manufacturer of distribution and control devices for industrial, commercial, and residential uses.

Size-marked for
quick identification in 42 stock sizes

And these precision-machined solid steel collars stay put because they are held in place on the shaft by the famous UNBRAKO Self-Locking Socket Set Screw. Authorized industrial distributors carry complete stocks in sizes from 3/8" to 3" inclusive. Write for Bulletin 868. STANDARD PRESSED STEEL CO., Jenkintown 39, Pa.

HALLOWELL POWER TRANSMISSION DIVISION SPS JENKINTOWN PENNSYLVANIA

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Mfrs. of Industrial Laboratory Recording and Dial Thermometers

Circle 119 on READ-N-CIRCLE card

new bulletins

. . . starts on page 20

431-Centrifugal pump primes itself

Self-priming stainless steel pump, described in Bulletin W-350-B13, can be used for chemical sump, tank car unloading, underground tanks, and applications where air or vapor handling capacity is required. Installation drawings and performance charts are included, together with physical properties of high-nickel, high-chromium, molybdenum alloy steel pump material. Recirculation port and details of mechanical or packed shaft seal are given. Eight pages. WORTHINGTON CORPORATION.

434-Piping flexibility analysis

Bulletin tells how to reduce cost of materials, design, and construction of processing and power piping systems. Includes development and solution of simultaneous equations for determining forces and moments in piping systems. Solves typical piping stress problem — high-temperature reheat system for utility central station—by both general analytical method and model test. Analyses permit specifications closer to the theoretically perfect pipe design. Twelve pages. FABRICATED PRODUCTS DIVISION, THE M. W. KELLOGG COMPANY.

435-Lattice mounts stem vibration

Rubber lattice mountings for low-frequency, high-amplitude vibrations are described in Bulletin 701. Lists types with static deflections from ¼ to 1½ inches and capacities from 250 to 3000 pounds per mounting. Includes easy-to-read reference table with complete dimensions and capacity data for heavy industrial equipment mounting. Four pages. LORD MANUFACTURING COMPANY.

436-Aluminum hoist is portable

Lightweight, aluminum alloy, portable chain hoist is described in Bulletin 146-G. Includes specifications, prices, and recommendations for use in vertical, horizontal, and angle pulling. Lists accessories for complete line of "CM" pullers in capacities from ¾ to 6 tons. Six pages. CHISHOLM-MOORE HOIST DIVISION, COLUMBUS MCKINNON CHAIN CORPORATION.

437-Capacitor-type fuel gages

Bulletin 546 discusses Liquidometer capacitor-type fuel gaging systems. Describes true weight gaging systems, compensated and uncompensated capacitor-type fuel gages, repeater indicators, fuel gage totalizing systems, selective indicators, and thermistor applications for fuel level warning and control. THE LIQUIDOMETER CORP.

438-Aluminum walls are practical

Curtain wall systems in new color finishes are discussed in "Wall Systems of Alcoa Aluminum." Contains up-to-the minute information on aluminum industrial building products. Also tells how colored aluminum can be used to complement color scheme or to emphasize safety code coloring. ALUMINUM COMPANY OF AMERICA.

439-Tachometer life is increased

Bulletin 105 tells how elimination of brushes, slip rings, and other parts needing regular maintenance has increased life of Metron tachometers 500 percent. Equipment is available for continuous steam records, over- and under-type speed alarms, and multiple recording from 2 to 10 indicators. Hundreds of combinations are available to meet exact speed measuring requirements. Four pages. METRON INSTRUMENT COMPANY.

441-Remove dust and fumes easily

Bulletin 60 describes equipment and procedures for fame elimination and dust removal. Lists Flexaust hose and Portovent duct prices and sizes from 1¼-inch to 36-inch id. Tells right way of cutting, coupling, and suspending flexible hose. Describes abrasive-resistant coatings and accessories. Gives temperature limits. Six pages. THE FLEXAUST COMPANY.

FREE COPIES

For free copies of these handbooks, bulletins, and catalogs just circle the key numbers on the READ-N-CIRCLE card on page 67.

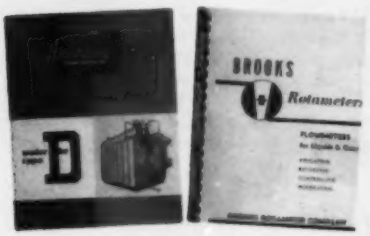
442-Plastic paints preserve

How "Seal-Kote" can be applied on either wet or dry surface, inside or out, is described in this bulletin. Can be used for painting cement and cinder blocks, concrete, brick, asbestos shingles, new and old wood, plaster, wallboard, all types of masonry, and asphalt. "Seal-Kote" permits free and constant "breathing" through its plastic film, thus re-

leasing all internal moisture. It is resistant to oil, grease, fats, fumes, and mild industrial acids. Provides a smooth surface for easy maintenance. THE WOOSTER SEALKOTE COMPANY.

443-Reduce transformer size

Oil-filled transformers from 100 kva to 5000 kva are described in this bulletin. New transformer design reduces size of unit without affecting capacity. Built-in oil level and temperature-indicator gages plus tap-changing mechanism are described. AIEE and NEMA accessories are included as standard equipment. MARCUS TRANSFORMER CO., INC.



444-Superior steam generation

Data and dimensional drawings in Catalog 102-D cover boilers from 8000 to 50,000 lb/hr firing oil, gas, or both. Catalog lists six advantages of completely assembled factory-engineered and tested packaged boiler units. Describes control for fully automatic firing either as a separate unit or as an integral part of boiler selected. Gives 14 features that result in better economy and performance. Twelve pages. SUPERIOR COMBUSTION INDUSTRIES INC.

445-All-purpose rotameter handbook

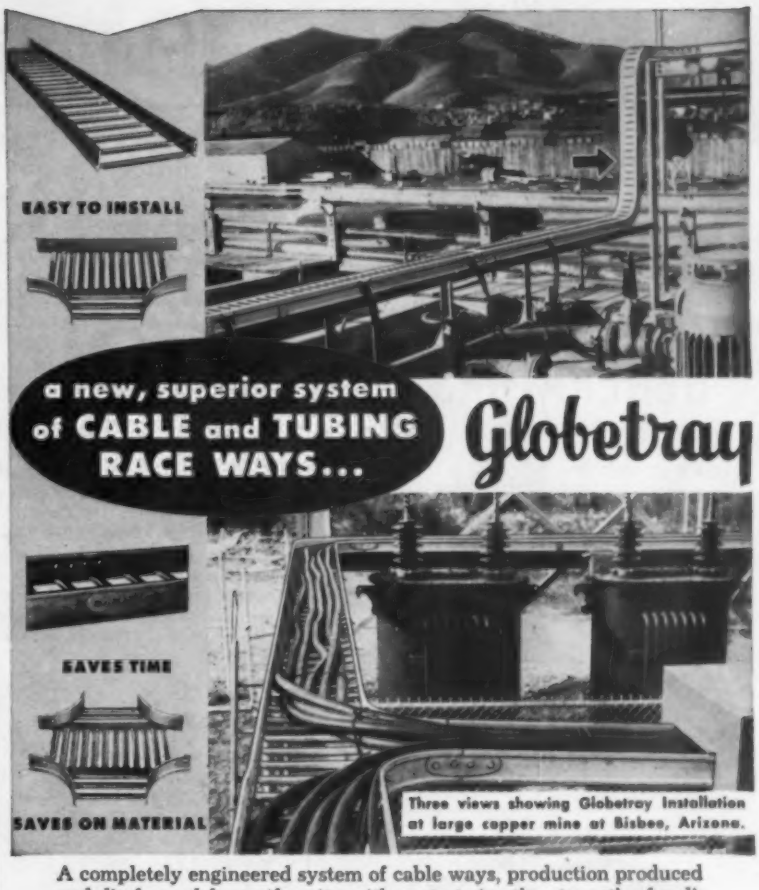
Illustrations and text in this catalog describe complete line of indicating, recording, controlling, and integrating flowmeters for liquid and gas measurement. Contains dimensional installation diagrams. Capacities; corrosion-resistant properties; and unique features of full-view, armored purge meters, and research rotameter equipment are given. Excellent reference catalog for engineers concerned with flow measurement. Sixty-eight pages. BROOKS ROTAMETER COMPANY.

446-Accurate downhill metering

Controlled volume pumps for "downhill" metering are described in Bulletin 855. Equipment can be used to advantage in additive injection, fluid sampling, and leakproof metering systems. Accuracies to within ±1 percent can be maintained. Four pages. MILTON ROY COMPANY.

447-Midget solenoid valves

Bulletin describes midget three-way solenoid valves in ⅛-inch pipe size. Dimension drawings and operating pressure ranges are given. Complete price list is included. Flow diagram shows operation of valves with solenoid energized and de-energized. AUTOMATIC SWITCH CO.



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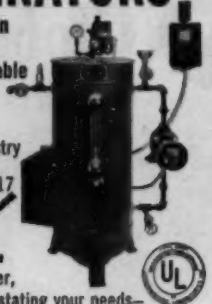
are available in all sizes—for every conceivable purpose!

Used by the leaders of industry throughout the world—Since 1917



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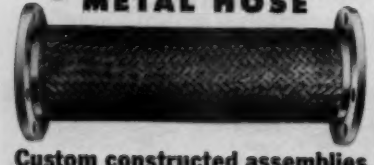

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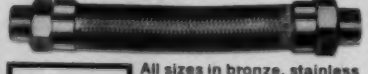

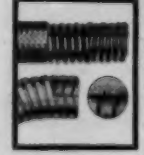

All sizes in bronze, stainless or carbon steel, monel, inconel and low carbon nickel. Seamless spiral or parallel corrugation... Braided. All type of fittings and flanges welded, brazed or soldered. Also, interlocked hose.

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free bulletins

. . . just circle key numbers on READ-N-CIRCLE card on page 67

Air cleaning equipment

500-Dust collector manual

Dust collectors, including cyclone, wet or dry dynamic, and cloth screen arrester types are the subject of a 32-page bulletin. Uses of air conditioning, ventilating, conveying, drying, and cooling units are presented. KIRK & BLUM MFG. CO.

501-Series on dust and fume collectors

Exhaust fans for dust collecting and air handling are described in Catalog 1002-6. Includes complete performance tables and test curves. Plans and elevations of typical installations are shown. Separate additional bulletins contain descriptions, dimensions, capacities of Norblo bag type, hydraulic type, and centrifugal dust collectors. THE NORTHERN BLOWER CO.

Boilers and boiler accessories

505-Boiler setting and baffle data

More than 30 boiler-setting plans are shown, with an analysis of how each arrangement of tubes is baffled to meet the specific boiler design, in 20-page Bulletin BW-54. THE ENGINEER CO.

506-What is a fan stack?

What a combined fan stack is, and what it does is described in Data Series 1-PDC along with details of construction of the stack and fan wheel. Twelve pages. THE THERMIX CORPORATION.

SUBJECT INDEX

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510-Package boiler improvements

Seven-page Bulletin AXY-1 gives full operating details and describes changes that have been made in the Amesteam generator, which is factory assembled, for 15 through 200 psi pressures. AMES IRON WORKS, INC.

512-Answers to hot water problems

Answers to your hot water problems are given in Booklet "Methods and Means." Operation and advantages of the instantaneous water heater as compared to the indirect method heater are thoroughly discussed and illustrated. PICK MANUFACTURING CO.

513-Handbook on startup

Handbook covers washing out new boiler, putting it in operation, handling in service, firing methods, and shut down. Includes big section of everyday engineering data. Forty-eight pages. TITUSVILLE IRON WORKS CO.

515-Steam cost calculator

Made of heavy board, this Steam Cost Calculator will enable you to read directly cost of steam per horsepower for installations using oil, coal, or gas. It also gives a direct reading of system efficiency. HAPMAN DUTTON CO.

Building construction materials

517-Mortar joints repaired simply

These seven simple steps for repairing worn or corroded mortar joints of brick or tile floors are presented in Bulletin E-37. Procedure involves use of nonshrink, Embeco pre-mixed mortar. THE MASTER BUILDERS CO.

521-How to build better masonry

Recommended practice covering materials, proportioning, mixing, and laying of units is offered in Bulletin WP6.55-35M. Three essentials to better masonry and four essentials to better mortar are given with quantity reference tables. Twenty-four pages. UNIVERSAL ATLAS CEMENT COMPANY.

Compressed air supply

523-Family-album compressor catalog

A family album showing all the compressors and centrifugal pumps manufactured by the company is presented in Bulletin 603. Thumbnail sketches and brief descriptions of each type with sources of further information are included. Six pages. PENNSYLVANIA PUMP AND COMPRESSOR COMPANY.

Electrical distribution

528-Current-limiting fuse charts

Hi-Cap fuses for maximum protection of loads above 600 amperes are described in detail in Bulletin HCS. Explains the use of these fuses with Fusetron fuses under most normal operating conditions. Illustrations and two handy charts are also included: Current Limiting Effect and Opening Time Curves. Six pages. BUSSMANN MANUFACTURING CO.

530-How to choose circuit breakers

Essential information on selection and application of molded case and large air circuit breakers is presented in this Speedfax catalog. Application sections make extensive use of charts and tables to explain selection of circuit breakers for motor circuits, bus duct, conductors, and transformer secondary applications. Also included are the latest prices, dimensions, and ordering instructions—arranged and indexed to reduce reference time and eliminate costly errors. Sixty pages. I-T-E CIRCUIT BREAKER CO.

Electrical utilization

532-Immersion heater data charts

Electric immersion heating elements for industrial, commercial, and domestic use are described in Bulletin EC-53. Contains data charts, descriptive material, and total wattage requirements for heating of solids, liquids, or gases. List of custom-made heaters is included for special industrial corrosive heating problems. Twenty-six pages. CUTLER-HAMMER, INC.

535-Lengthen your battery life

Storage-battery selection, charging, handling, maintenance, inspection, and testing for switchgear control are covered in the Plus-Performance Plan. Performance can be improved and battery life extended by as much as 50 percent. Read how in this collection of articles, specifications, charts, record systems, manuals, and bulletins. GOULD-NATIONAL BATTERIES, INC.

Engines: diesel, gas, steam

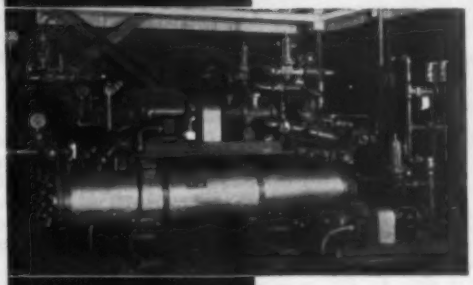
537-More profit with turbodiesels

What is a turbodiesel? The answer to this question along with the answers to greater fuel economy, more power without increased size, and reduced engine waste per horsepower are contained in Bulletin 12009. Four-color bulletin contains illustrations and easy-to-understand description of the operation of turbochargers on diesel engines. Also contains specifications and performance curves for four industrial diesel engines. Comparisons of fuel economy, horsepower, and reduced weight for naturally aspirated, supercharged, and turbodiesel engines are shown. Sixteen pages. CUMMINS ENGINE COMPANY, INC.

ENCO
Fuel Oil Pumping and Heating Systems

For heavy bunker oil or light furnace oil . . . 100 to 10,000 gallons per hour

Enco systems employ one, two or more pumps and heaters, interconnected so that full capacity is possible with any combination of pumps and heaters. Flexibility of design permits the use of any combination of rotary pumps, with motor or turbine drive; or piston type steam pumps. Any part may be cut out of operation for inspection or cleaning, without shutting down, where two or more pumps and heaters are included in the unit system.



Heaters are insulated and jacketed with removable heads at both ends for cleaning without breaking any piping connections or removing any tube bundles.

Full automatic oil pressure and temperature control, with relief valves for each pump and heater. Permits delivery of oil with safety, and at proper temperature and pressure for efficient burning.

Each unit is built to order and delivered ready to place on foundation and for connection to the station piping.

Write for Bulletin OB-53 describing Enco Gas and Oil Burners; and Pumping and Heating Equipment.

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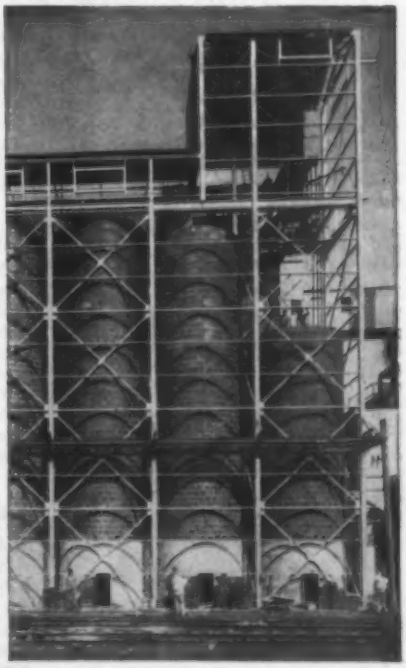

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Corrosion-resistant vitrified glazed tile double-wall blocks made in *Kalamazoo's* own plant. Corrosion-proof mortar joints.

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Fuels and firing equipment

540-Modern ways of burning coal

"Burning Bituminous Coal the Modern Way," contains 24 pages of case histories from industries of all sizes and types. Engineering survey results for equipment include annual fuel consumption and operating costs. BITUMINOUS COAL INSTITUTE.

542-Fuel oil preheaters save $ $ $

Two-page Bulletin 54-79-1 explains how the right fuel oil preheater can save costs by using lower grade fuel oil. Installation instructions, specifications, and capacities are listed for 2-pass and 6-pass preheaters. AMERICAN DISTRICT STEAM CO., INC.

Instruments and controls

544-How to select liquid-level control

Bulletin-1 discusses the factors to be considered in selecting a liquid-level control. It includes controls in types and sizes for handling practically any liquid, at any pressure and any temperature. Eight pages. MAGNETROL, INC.

546-Hot-water boiler safety controls

Safety valves, low-water fuel cutoffs, and feeder cutoff combinations are described with engineering data in Bulletin P-30. Common questions about hot-water boiler safety are answered with the aid of colored diagrams. Eight pages. MCDONNELL & MILLER, INC.

551-How to select temp control

Temperature ranges and other properties of liquid expansion, gas-pressure, and vapor-pressure filled systems are tabulated to aid in selection of control systems for any application in Catalog 12-A-10. Instruments for indicating, recording, controlling, and programming temperatures from -400 to +1000 F are also described. Twenty-four pages. FISCHER & PORTER CO.

Lubrication

553-Do's and don'ts for bearings

A helpful list of "do's" and "don'ts" to prolong bearing life appears in Bulletin 506. Also included is information on the storage and handling of industrial lubricants. Four pages. NEW YORK AND NEW JERSEY LUBRICANT CO.

Maintenance items

554-Hardness data card

Hardness conversion chart shows the approximate relation between hardness values obtained by various testing systems and the tensile strength of carbon and alloy steels. Hardness systems covered in Bulletin TDC-183 are Brinell, Monotron, Vickers, and Rockwell. THE BABCOCK & WILCOX COMPANY.

556-Repair methods handbook

Text and illustration in this 48-page handbook present repair methods for leaks in pipes, boilers, radiators, concrete, cinderblocks, and sheet and plate metal. Directory describes 12 repair cements and jobs they will do. SMOOTH-ON MFG. CO.

FREE COPIES

For free copies of these handbooks, bulletins, and catalogs just circle the key numbers on the READ-N-CIRCLE card on page 67.

558-High pressure welding electrodes

New line of low-alloy steel arc welding electrodes for boiler repairs and high pressure piping fabrication is contained in Bulletin 55CM. Electrodes eliminate weld cracking and reduce stress-relieving to a minimum. Preheat temperatures can be decreased to reasonable levels, permitting easy field welding. THE CHAMPION RIVET COMPANY.

Materials handling (bulk)

560-How to store bulk materials

Storage bins for bulk materials such as ashes, coal, coke, sand or lime are fully discussed in this bulletin. Contains tables of densities of flowable materials, capacities, description of wall construction, test data, and other relevant engineering data with many photographs, and line drawings. Twenty-nine pages. THE NEFF & FRY CO.

561-Are you venting tanks properly?

How to vent flammable liquid-storage and process tanks for effective operation, fire protection, and low-cost maintenance is described in this bulletin. Illustrated sections are devoted to conservation-type, and non-conservation-type venting. Sections are also devoted to flame arrester units, protective devices for fuel tanks on industrial equipment, and protection in loading and unloading tank cars. Twelve pages. THE PROTECTOSEAL COMPANY.

Mechanical power transmission

564-Fluid drive selection guide

New fluid drive for general purpose industrial adjustable speed applications is discussed in Bulletin 9419-9519. Advantages and applications are described, emphasizing such factors as speed control, power savings, no-load starting, torque limitation, acceleration control, shock absorption, and simplified installation. Tables indicate the proper fluid drive to use with drive motors rated from 7.5 to 800 hp. Eight pages. AMERICAN BLOWER CORPORATION.

565-Need a speed changer?

Operating advantages of "Vari-Pitch" speed changers are described in Bulletin 20B6013D. Available in twelve sizes from 1 to 75 hp with output speeds ranging up to 2900 rpm. Speed changers operate in either vertical or horizontal position. Suitable for reversing service with addition of a simple, low-cost tension stabilizer. Includes arrangement diagrams, selection and speed range tables. ALLIS-CHALMERS MANUFACTURING COMPANY.

567-V-Belt rating manual

"Multi-V-Drives," this 100-page master engineering manual presents a scientific and simplified method for rating V-Belts. In addition to accepted theories on V-drive engineering, factors such as small diameter sheaves, centrifugal force, average hours per day operation, and other conditions affecting belt lines have been considered. WORTHINGTON CORP.

Piping, tubing, and hose

570-Corrugated flexible metal hose

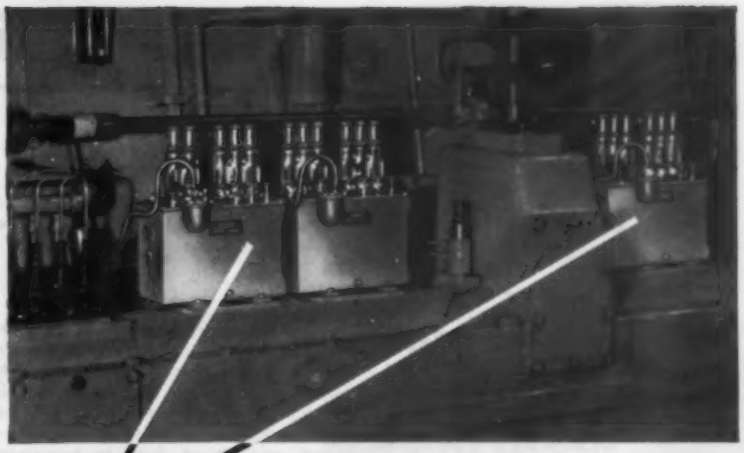
Complete engineering data including bending radii, bursting pressures, and weights, are included in Bulletin 20-E. Applications are listed for absorbing vibration, correcting misalignment, connecting oil burners and gas furnaces, lubricating lines, and conveying compressed air and steam. THE ATLANTIC METAL HOSE CO.

574-Expansion joint selection guide

This data book is a must for any engineer interested in expansion joints. Catalog 135 contains piping layouts, installation instructions, and specifications. Also includes angular and lateral motion charts and 19 engineering tables. Twenty-six pages. FLEXONICS CORPORATION.

577-Centrifugal pump manual

Dimensional drawings, selection charts, and performance tables for the complete line of general purpose centrifugal pumps are included in Bulletin 7223-A. Suction and discharge positions, as well as V-belt, direct drive, and gear drive modifications, are also shown. Bulletin gives data on pumps with capacities of from 5 to 2800 gpm, and operating pressures of from 10 to 525 feet total head. Includes in-



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stallation examples for the complete line of general purpose centrifugal pumps. Sixteen pages. INGERSOLL-RAND.

578-How to use package feeders

Proportioning pumps and package chemical feeding units are described in this four-page folder. With liquid ends available for about 85 percent of all chemical pumping requirements, the pump is designed for use where a controlled capacity of fluid is necessary. How feeding unit is connected to plant piping and to electrical control equipment is explained. BIRD-ARCHER CO.

Pumping equipment

579-How to figure pump heads

How to determine total head against which pump must operate is only one of the valuable sections in 12-page Bulletin 353-1000 on the Bilton pump, a general purpose pump suitable for medium and low head service. BYRON JACKSON DIVISION, BORG-WARNER CORPORATION.

580-Sewage and sump pump selection

Comprehensive, eight-page Bulletin 325-A32 is for engineers, architects, and contractors who specify sewage and sump pumps. It describes in detail three types of pumps: The NKS Vertical Wet Pit Single or Duplex; the NKV Vertical Dry Pit; and the NKH Horizontal. AMERICAN-MARSH PUMPS, INC.

Refractories and insulation

582-Refractory construction

The different types of construction considered standard for industrial refractory are described in Bulletin 39. Profusely illustrated. Twenty pages. BIGELOW-LIPTAK CORP.

Traps, strainers, and separators

583-Steam trap handbook

Catalog 68G, 31 pages, describes and illustrates complete line of steam traps, strainers, regulating and reducing valves, separators, and vacuum and lifting traps. STRONG, CARLISLE & HAMMOND COMPANY.

584-Traps fit all needs

Ball float traps for draining water from air, gas, or steam lines or for draining light liquids from gas under pressure are described in eight-page Bulletin 289. An orifice capacity chart and tables of maximum operating pressures help in selection. ARMSTRONG MACHINE WORKS.

Turbines

585-Steam-turbine selection curves

Horsepower selection curves for the complete line of horizontal and vertical steam turbines are contained in Bulletin 500. Includes overall installation dimensions for vertical and horizontal DH steam turbines. Typical installations of additional accessories are shown. Sixteen pages. DEAN HILL PUMP COMPANY.

586-Speed control fundamentals

"Fundamentals of Turbine Speed Control," 32-page Brochure H-21, is an educational piece intended to clarify the operation of common types of automatic speed control for steam turbines. Simplified diagrams illustrate operating principles of actual control systems. ELLIOTT CO.

587-Design of multistage turbines

Smaller framed, multistage turbines are featured in six-page bulletin. Overspeed governor, governor valves, blades, diaphragms, and many other design features are discussed in detail. TERRY STEAM TURBINE CO.

Valves and regulators

589-Control valve reference book

Three basic types of single-seated diaphragm control valves are discussed in 15-page Bulletin 5304. Cutaway views and charts with complete specification data make this a good reference book. LESLIE CO.

590-Read about control valves

Discussion of equipment for the control and regulation of steam, water, air, oil, and gas is contained in composite Bulletin C-50. This bulletin also contains descriptions of proper application for all pressure, flow, and liquid level controls. Four pages. MCALEAR MANUFACTURING COMPANY.

591-Rubber lining combats corrosion

Fully revolving double-disc parallel-feed gate valve lined with special hard-rubber lining is described in this bulletin. Revolving disc principle distributes wear over 360 degrees. Included are dimension drawings for rubber-lined gate valves and swing check valves. Four pages. DARLING VALVE & MANUFACTURING CO.

592-Accurate valve sizing manual

Comprehensive and easy-to-understand discussion of the importance of proper valve sizing is contained in Bulletin 120-

2-55. Also contains formulae and nomographs for sizing valves to meet any conditions of steam, liquid, and gas flow. Additional tables of flow coefficients for the many configurations of diaphragm-control inner valves are also given. Twenty-four pages. BLACK, SIVALLS & BRYSON, INC.

593-General-purpose valve manual

Gate, globe, and angle valves in sizes from ¼ through 2 inches are described in Bulletin F-9, supplement 1. Also includes pressure-temperature rating chart for carbon and alloy steel valves. Dimensional-sectional views of 11 available valve configurations are given. Includes price list for complete line of valves. An excellent manual for the engineer faced with a valve or piping problem. Thirty-two pages. HENRY VOGT MACHINE CO.

594-Steam-jacketed valves illustrated

"Viscous Materials," four-page Folder E-200, will be of special interest to engineers of plants in which viscous materials are handled. Illustrations of steam-jacketed valves include a cross section and an exploded view. EVERLASTING VALVE CO.

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595-Why not a solenoid valve?

If you use direct operated solenoid valves for automatic or remote flow control of liquids and steam up to 400 F, or of high viscosity liquids you will want to read 11-page Bulletin V-2. Normally closed, normally open, explosion-proof normally closed, and three way valves are shown. THE JOHNSON CORP.

596-Simple valve cross-index

Valve users can easily obtain data on valves for a wide variety of applications by using the simplified cross index in 27-page Catalog 105. The most widely used cast and forged steel Edward globe and angle stop, non-return, check, gate, hydraulic, relief, mudline, flow-off, instrument valves, and strainers are included. EDWARD VALVES, INC.

Vibration and noise control

597-Vibration encyclopedia

This nine-chapter booklet discusses meaning of vibration terms, vibration-measuring instruments, procedures, typical examples, and interpretation of results. Describes decibel conversion tables, vibration meters, and vibration analyzer equipment. A short section is devoted to the human response to mechanical vibration. Sixty-four pages. GENERAL RADIO COMPANY.

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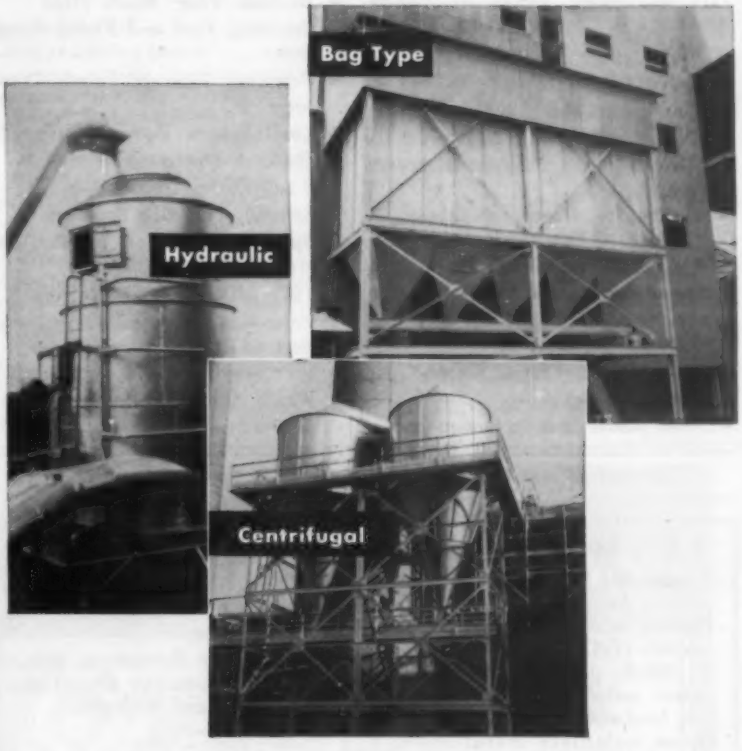

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Special Report reprints

Individual copies of Special Report Reprints will be sent free upon request. Additional copies are priced as follows: 2 to 24 copies are 25¢ each; 25 to 49 copies are 20¢ each; 50 to 99 copies are 15¢ each; more than 99 copies are 10¢ each. Special Report Reprints available are:

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2 Babcock & Wilcox 600 HP each, Sterling bent tube, 4-drum, new 1939-40, ASME built, Hartford Inspection HSB-11925, Class 50, No. 23, 200-lb. design, complete with stokers, meters, ash conveying system, feed water system, oil remover system, complete installation, erected Chicago as last used until Summer 1955; tremendous bargain, inspection invited, communicate with owners. Box B-22, Industry & Power, St. Joseph, Michigan.

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598-Control pipeline surges

Magnilastic Hydropads for elimination of water hammer, and dampening of pulsations induced by reciprocating pumps are described with engineering data in Catalog 52. Units can also be used as accumulators in hydraulic systems and for accommodation for excess fluid volume that results from thermal expansion. A table on determination of expansion in pipelines heads a section on expansion joints. Thirty-six pages. COOK ELECTRIC COMPANY.

599-Vibration engineering specs

Complete specifications and performance data for vibration, shock, and noise control products are available in Bulletin K4A. Eleven different types of vibration isolating units are presented. Detailed discussion of the relative merits of springs and organic materials as isolating media is given. Includes an easy-to-read selector chart. Four pages. KORFUND CO.

Waste disposal

600-Refuse and wood burning

Engineering data concerning spreader stokers installed to burn refuse or wood are contained in 24-page Booklet 505. Stationary, manual dumping, power dumping, and traveling grate installations having maximum capacities from 10,000 to 275,000 pound steam per hour are described. DETROIT STOKER CO.

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Water supply and treatment

601-How to supply your own water

Methods of abstracting water from the ground or by infiltration through permeable beds of rivers or other bodies of water are discussed in 20-page bulletin. Performance charts for this company's collector are supplemented with cross-sectional drawings and cutaways. RANNEY METHOD WATER SUPPLIES, INC.

602-All phases of purification

"Boiler Feedwater Treatment," 19-page Bulletin BFT-1, covers Inversand zeolite softeners, color process chemical softeners, and demineralizing units, including silica removal by ion exchange. HUNGERFORD & TERRY, INC.

603-Demineralizing handbook

"Handbook on Demineralizing," Bulletin 5800-B, compares various methods of water treatment including demineralizers and evaporators. It goes into characteristics of various types of available cation and anion exchange materials. Forty pages. COCHRANE CORP.

604-Clean your boiler in operation

How to clean your boiler while in operation is explained in four fact-filled pamphlets. The Ever Clean boiler process removes rust, prevents corrosion, and increases boiler efficiency. Also includes data on solving algae problems. NORTH AMERICAN MOGUL PRODUCTS.

605-Acid on cooling towers

Discussion of how chemical and bacteriological attack can be controlled by acid treatment and wood preservatives to kill fungi appears in Technical Paper No. 130. A good reference work for anyone interested in cooling towers. Eight pages. W. H. & L. D. BETZ.

606-Pocket-size water testing kit

Water hardness can now be measured to the nearest 0.2 grain per gallon in an on-the-spot test that takes only one minute. Three-ounce kit consists of a glass vial and a bottle of reagent, is contained in a plastic box. Details of the Zeo-Kit are given in Bulletin 7RE55. CALGON, INC.

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Before you decide... survey diesel engine starting systems

There are several methods of starting diesel engines available today, and a diesel installation is no more reliable than its starting system. Your choice will be influenced by the operating conditions and climatic conditions under which your engine will work. T. A. Willey, Engine Division of Caterpillar Tractor Co. writes about starting systems, their applications and shortcomings.

Read how to make a more intelligent purchase, and gain a better appreciation of what diesels can do for Industry's Power Services in the

March issue of
INDUSTRY & POWER

coming events

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Feb. 6-9	Fifth Annual Industrial Ventilation Conference	Kellogg Center Michigan State U.
Feb. 9	ISA Annual Mid-winter Conference	Hotel Statler New York City
Mar. 8-9	AIEE Conference on Electrical Engineering	Univ. of Florida Gainesville, Florida
Mar. 18-21	ASME Spring Meeting	Multnomah Hotel Portland
Mar. 21-23	American Power Conference	Hotel Sherman Chicago
Mar. 26-27	ASME Instruments and Regulators Conference	Princeton Univ. Princeton, N. J.
Apr. 1-5	ASME Oil, Gas, and Power Conference	Jung Hotel New Orleans
Apr. 2-4	AIEE Southwest District Meeting	Dallas
Apr. 5-7	Eighth Biennial Electric Industry Show	Shrine Hall Los Angeles
Apr. 16-17	ASME Gas Turbine Power Division Conference	Hotel Statler Washington, D. C.
Apr. 16-18	AIEE Great Lakes District Meeting	Fort Wayne Indiana
May 2-4	AIEE Northeast District Meeting	Rochester, N. Y.
June 17-21	ASME Semiannual Meeting	Statler Hotel Cleveland

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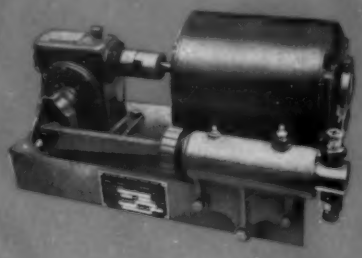
pump or packaged unit



PHILA-FEEDER

most dependable, low-cost means of feeding water-treating chemicals.

Made by the makers of the most complete line of controlled capacity chemical pumps.

● Self-contained chemical feed units comprise single or divided welded steel tanks, simplex or duplex PHILA-FEEDER pumps, gages, strainers and all necessary piping for proportioning chemicals into plant system.

PHILADELPHIA PUMPS

PHILADELPHIA PUMP & MACHINERY CO. / 1513 Race St., Phila., Pa. / Subsidiary of American Meter Co.

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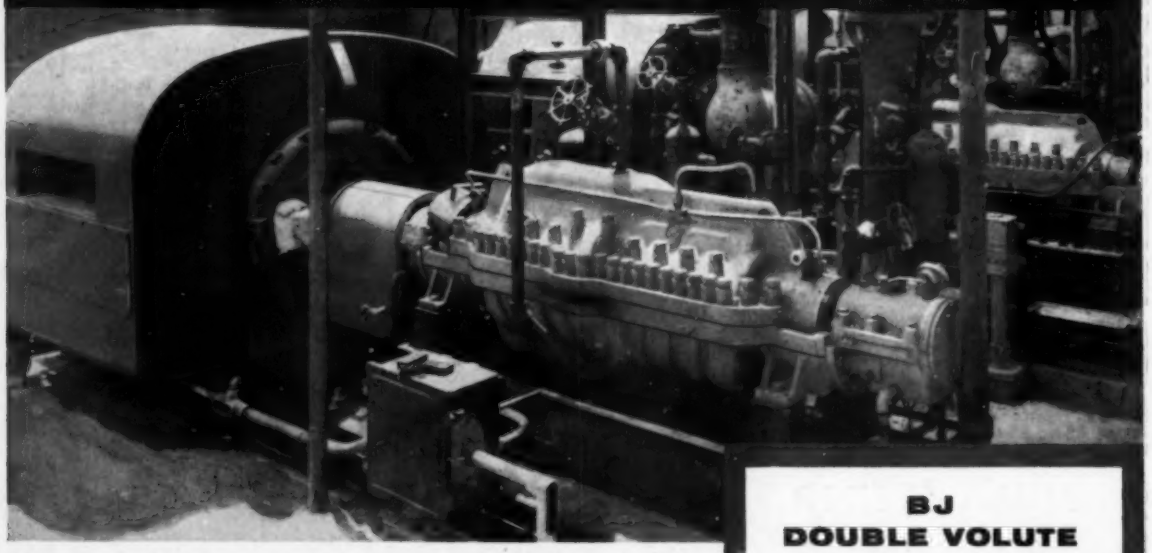
NEW Byron Jackson DVMX
SPLIT CASE BOILER FEED PUMP

...Engineered for Medium Size Power Plants



This new Byron Jackson DVMX split case pump gives the same trouble-free service that BJ barrel type Boiler Feed Pumps have been providing for the larger power plants in the United States for many years. This DVMX model is engineered primarily for medium-sized power plants and delivers capacities to 2200 gpm, heads to 1200 psig. and temperatures to 350° F.

Here's what you get in the new DVMX

1 Horizontally-split case, with both nozzles in the lower half of the pump case, permitting removal of the top half of the case and the complete rotating element without disturbing the piping.

2 Double volute design which assures radial balance of the pump at all capacities.

3 Impellers arranged in equally opposed groups, assuring hydraulic axial balance without resorting to the use of any auxiliary high pressure balancing devices.

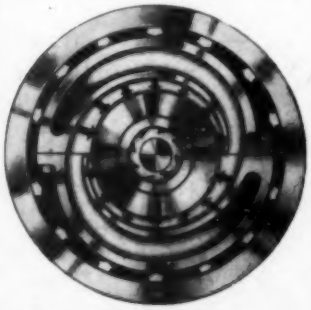
4 Available with reliable BJ high pressure Mechanical Seal especially designed for boiler feed service.

5 Furnished with a spacer type coupling for easy removal of the mechanical seal.

6 The thrust and radial bearings including the self-contained oiling system are of the same reliable construction that has proven so successful over the years in the larger BJ barrel type Boiler Feed pumps. The oiling system is of ample size to supply the driver bearings if desired.

BJ DOUBLE VOLUTE

By the use of BJ Double Volute inner cases, the flow is divided into two identical fluid channels with outlets 180° apart. Equal opposing forces are created, resulting in radial balance without pressure-bending moment on the shaft.



BJ MAKES BOILER FEED HISTORY!

Byron Jackson is building the world's largest boiler feed pump. This 12,000 HP pump will deliver 6,330 gallons per minute at total head of 6,400 feet, or about 2700 pounds per square inch, at a speed of 3510 RPM.

Byron Jackson

Division of Borg-Warner Corporation
P.O. 2017, Terminal Annex, Los Angeles 54, California

BJ

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